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DEFENCE RESEARCH GROUP

PANEL 8 ON THE DEFENCE APPLICATIONS OF HUMAN AND BIO-MEDICAL SCIENCES

RESEARCH STUDY GROUP 8 ON NUTRITIONAL ASPECTS OF MILITARY FEEDING

NATO — OTAN

MILITARY NUTRITION

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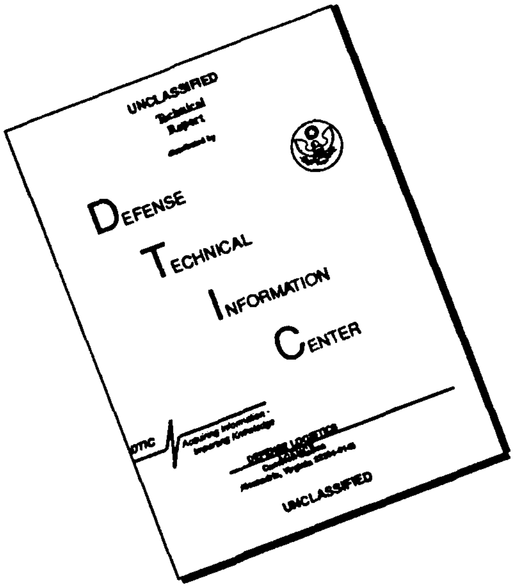

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14. Abstract: The report contains agreed nutritional criteria for operational rations and garrison feeding and provides nutritional recommendations for alimentation of wounded personnel. Nutritional guidance to sustain physical performance during prolonged work and during exposure to climatic extremes is also provided. The report contains a summarized description of the nutritional composition and purpose of current NATO countries' survival, emergency and combat rations. Detailed methodologies are described for nutritional evaluation of military rations and feeding systems as well as procedures for assessment and evaluation of nutritional status to include obesity and its relationship to health and performance. The relationship of diet to coronary heart disease risk factors is reviewed and guidance is provided for nutritional education programmes designed to implement agreed dietary goals for military populations. The report identifies areas of inadequate information and provides recommendations for further research and study. The military implications of the findings in this report are described.

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DEFENCE RESEARCH GROUP

PANEL 8 ON THE DEFENCE APPLICATIONS OF HUMAN AND BIO-MEDICAL SCIENCES

RESEARCH STUDY GROUP 8 ON NUTRITIONAL ASPECTS OF MILITARY FEEDING

Final Report on Military Nutrition

This is the final report drafted by RSG.8 on Nutritional Aspects of Military Feeding, under the Chairmanship of Col. Schnakenberg (US). The editing of this report should be contributed to Lt.Col. J.S.A. Edwards (UK). The Executive Summary of this report has also been issued under reference AC/243(Panel 8)D/134 dated 1st December 1989.

(Signed) V. LEMCHE
Defence Research Section

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CHAPTER 0

EXECUTIVE SUMMARY

0 OVERVIEW OF THE STUDY

I. Research Study Group 8, (RSG 8), Nutritional Aspects of Military Feeding, was formally established and Terms of Reference (TOR) approved at the November 1981 meeting of Panel 8 in response to recommendations developed at an Exploratory Group (EG) meeting hosted by the UK in October 1980. The objectives outlined in the TOR were as follows:

* Main Objectives

  + To promote active collaboration on research topics for the establishment of nutritional requirements, in their broadest sense and taking into account nutritional status, for both operational and peace-time conditions.

  + To foster agreed research methods to meet these needs.

* Technical Objectives

  + Nutritional and Operational Performance Effectiveness. To study the importance of diet, including water, for the sustenance of military personnel under all operational conditions, such as sleep deprivation, climatic extremes, atmospheric pressure variations, time-zone transportation, sustained operations, survival situations and NBC warfare.

  + Improvement of Nutritional Status. To develop common methods of measurement and assessment for nutritional status and obesity with the ultimate aim of agreement on desirable body composition standards for military personnel.

  + Prevention of Disease and Promotion of Health. To study nutritional factors in the causation of diseases of military importance with the objective of developing an agreed military policy on good dietary practices for all members of the Armed Services.

II. Progress towards these objectives was reported and coordinated at workshop meetings held:

USA May 1982	CA October 1986
NL October 1983	BE April 1987
FRG June 1985	USA November 1987

III. The information provided in the report was drawn from the published literature with particular emphasis from those studies conducted with military populations by member countries. It should be noted that major proportions of the data presented are drawn from studies conducted by member countries since 1982 when the RSG-8 held its first meeting

IV. The report contains agreed nutritional criteria for operational rations and garrison feeding and provides nutritional recommendations for alimentation of wounded personnel. Nutritional guidance to sustain physical performance during prolonged work and during exposure to climatic extremes are also provided. The report contains a summarized description of the nutritional composition and purpose of current NATO countries' survival, emergency and combat rations. Detailed methodologies are described for nutritional evaluation of military rations and feeding systems as well as procedures for assessment and evaluation of nutritional status to include obesity and its relationship to health and performance. The relationship of diet to coronary heart disease risk factors is reviewed and guidance is provided for nutritional education programmes designed to implement agreed dietary goals for military populations. The report identifies areas of inadequate information and provides recommendations for further research and study. The military implications of the findings in this report are described.

0.2 SUMMARIES AND MAIN CONCLUSIONS

0.2.1 Nutrient Requirements of Military Personnel

V. Nutrient requirements, including water, and recommended dietary intakes for military personnel are, by their very nature, an imprecise calculation especially when applied to individuals. However, data and recommendations for military population groups were reviewed, assessed and summarized (Chapter 2). Most NATO armed forces, in formulating recommendations, generally follow their own country's guidelines with adjustments for increased levels of physical activity. Chapter 2 contains data on the daily energy requirements for different activities (Table 2.4) and water requirements for different activity levels at different air temperatures (Table 2.7). There is scientific basis for adjusting the food supply for military personnel operating in hot, cold and high altitude environments. The current recommended intakes of protein, vitamins and minerals for military personnel of the RSG-8 member nations was summarized in Table 2.9. The RSG-8 reviewed and provided technical input for agreed nutritional guidelines for survival, emergency and combat rations as described in NATO STANAG 2937.

0.2.2 Nutrition and Performance

VI. The physical performance demands of military personnel range widely depending on a number of factors including individual trade, mission and environmental factors. The use of nutritional strategies to optimize

...nse is therefore of direct military interest. Current knowledge in this area, as affecting the military population, was considered and evaluated (Chapter 3). When the intramuscular stores of carbohydrate, in the form of glycogen, are depleted, subsequent exercise performance is impaired. There is direct evidence that muscle glycogen stores of military personnel are markedly depleted at the end of exhaustive combat field trials. There is experimental evidence that the consumption of >450 g of carbohydrate per day is required to facilitate glycogen resynthesis. There is limited experimental evidence that metabolic adaptation to a calorie dense, fat rich, i.e. carbohydrate poor diet may be possible although the time course and extent of adaptation must be clarified before such a diet can be applied in a military setting.

VII. There is no consistent evidence to suggest that the capacity to perform physical exercise would be enhanced by the addition of micronutrients in excess of known requirements. There is some limited data to suggest that the ingestion of the amino acid tryptophan may be beneficial in increasing sleep time and avoiding subsequent performance impairments of personnel transported across time zones. The current data base on the effects of dietary manipulation on mental performance is meagre at best.

VIII. Calorie restriction causing gradual weight loss of up to about 10% will not cause drastic performance deficits and therefore calorie restricted rations are feasible for selected short duration military operations where reduced food weight and volume would be advantageous.

0.2.3 Diet and Coronary Heart Disease Risk Factors

IX. The relationship between diet and coronary heart disease (CHD) was reviewed (Chapter 4) and the relative risk of CHD seems to be similar in civilian and military populations. Serum total cholesterol, HDL cholesterol and the ratio total/HDL cholesterol have been established as predictive indicators of CHD risk. Excessive consumption of total fat, in particular, saturated fat and to a lesser extent, dietary cholesterol has been shown epidemiologically and clinically to be positively associated with increased CHD risk factors. Clinical trials have indicated that dietary intervention (reduced fat, total fat and cholesterol intake) can reduce CHD risk factors.

0.2.4 Body Composition and Relationship to Health and Performance

X. Excess body fat contributes to decreased physical performance of military personnel and is associated with increased health risks. Although there are numerous methods available to assess body fat (Chapter 5), these are of varying accuracy and only a few methods (height/weight indices, circumferences and skinfolds) are feasible for large groups of military personnel. The Durnin skinfold method has been applied in research studies of large numbers of UK, NL, US and CA male and female military personnel and these data are summarized in Chapter 5. However, there is no agreed

single method for measuring body composition among the member nations and only the US and Canada have established body composition standards in the implementation of the weight control programmes.

1.2.5 Alimentation of Military Casualties

XI. Depending on the extent of the injury and subsequent surgery, wounded persons present a high catabolic state requiring aggressive nutritional support to speed recovery. Examples of alimentation programmes involving oral, tube or parenteral feeding are described in Chapter 6.

1.2.6 Rations of Selected NATO Countries - Purpose and Nutrient Composition

XII. All NATO countries participating in RSG-8 make use of packed rations as part of their overall feeding philosophies. The purpose and nutritional composition of survival, emergency and combat rations of each member country are described and summarized in Chapter 7. These rations currently tend to be diverse in their content, design and to some extent their nutritional composition. Several member countries have made or are in the process of making changes to their rations to improve acceptability and lower the fat content to comply with agreed nutritional guidelines of NATO STANAG 2937.

1.2.7 Garrison and Combat Feeding - Optimizing and Evaluating Consumption

XIII. The ultimate objective in military feeding is to provide the soldier with a healthy balanced diet, to stated nutritional criteria, which is of maximum acceptability and within the constraints of cost and available logistics. Monitoring the success of these objectives is likewise essential. Chapter 8 provides a detailed description of techniques which have been used by various member countries to measure food preference, food acceptance and food and nutrient intakes. The results of combat ration trials and garrison feeding studies conducted by member nations since the formation of RSG-8 are also summarized and evaluated in this Chapter. The results of the ration trials have demonstrated that poor acceptability of certain items leads to inadequate energy consumption and body weight loss. Two studies have been conducted to evaluate the possible beneficial effects of a nutrient solution (compared to water alone) to maintain performance of personnel wearing NBC protective clothing for extended (8-24 hr) periods. The results to date have been inconclusive. In general, the fat intakes at garrison situations, in all countries studied, exceed the recommended level of not more than 35% of calories from fat sources.

0.2.? Nutrition Education: Implementation of Dietary Goals

XIV. Nutrition education is a critical factor in the health and physical performance of an individual and therefore affects the operational readiness of a military force. Nutrition education is an effective measure of improving nutrition related behaviour. Examples of nutrition education programmes and materials currently being used in the CA, UK and US are described in Chapter 9. The importance of modifying the menus, changing the recipes and training the cooks as well as educating the diners in good nutritional habits is also discussed. There have been no objective studies to evaluate the effectiveness of the nutrition education programmes in a military situation.

0.3 MAJOR RECOMMENDATIONS

0.3.1 Nutrient Requirements of Military Personnel

XV. The recommended dietary intakes presented in Chapter 2 are based upon the information currently available and should be adopted by all NATO nations in the monitoring and evaluation of protein, vitamin and mineral intakes of military personnel.

XVI. Adjustments of the food supply, in particular energy and carbohydrate, should be made for military personnel operating in hot, cold and high altitude environments.

XVII. The fact that water requirements are increased by vigorous physical activity and elevated environmental temperatures should be considered in logistical planning of the water supply.

0.3.2 Nutrition and Performance

XVIII. A carbohydrate intake of at least 450 g per day is recommended to facilitate muscle glycogen resynthesis of personnel engaged in sustained exhaustive physical activity.

XIX. Further research is needed to develop and evaluate nutritional strategies on nutrient supplements to maintain optimal performance of mental or military specific tasks during environmental or operational stress.

XX. Certain operational scenarios (i.e. long range patrols without resupply) may require deviations from accepted nutritional guidelines. Such deviations should not extend beyond 14 days until such time as research is carried out to document the possible performance and health implications.

[illegible] Research should be undertaken to evaluate the effects of [illegible] (i.e. > 60% fat/calorie) diets for several weeks, [illegible] of metabolic adaptation, and the implications for physical [illegible] performance as well as health.

[illegible] Diet and Coronary Heart Disease

XXII. In order to identify those individuals at increased risk from coronary heart disease, periodic blood lipid tests (cholesterol, high and low density lipoprotein) should be carried out and appropriate intervention, including nutritional counselling, should be administered to [illegible] at increased risk.

[illegible] Body Composition and Relationship to Health and Performance

XXIII. Consideration should be given to developing a NATO standard to [illegible] overweight and obesity.

XXIV. For applications in a military setting, body composition methods involving weight-height indices, skinfolds or circumferences are recommended.

[illegible] Alimentation of Military Casualties

XXV. Alimentation programmes involving oral, tube or parenteral feeding should be used to provide nutritional support and speed recovery of military casualties.

XXVI. Further research is needed to define the optimal support for traumatized casualties during wartime.

6.2.6 Rations of Selected NATO Countries - Purpose and Nutrient Composition

XXVII. The nutritional content of the survival, emergency and combat rations of all member nations should be adjusted as required to meet the nutritional guidelines provided in NATO STANAG 2937.

XXVIII. All member nations should determine the nutrient composition, to include vitamins and minerals, of their packed rations.

6.2.7 Garrison and Combat Feeding - Optimizing and Evaluating Consumption

XXIX. Each nation should introduce a programme of food acceptance and nutritional evaluation of their own packed rations or combat feeding systems using, where possible, the methods identified in this report.

XXX. The possibility should be explored, during a major NATO exercise, of exchanging combat rations, monitoring food acceptance and nutritional intake with a view to further standardizing or increasing the interoperability of either individual components or complete rations.

XXXI. There is a priority requirement to conduct further research on the possible beneficial effects of a nutrient solution (compared to water alone) to maintain performance of personnel wearing NBC protective clothing for extended (6-24 hr) periods.

XXXII. Each member nation should introduce a programme to ascertain the current dietary intake in Garrison dining facilities. Particular emphasis should be placed on monitoring fat, saturated fat, cholesterol and salt intakes.

0.3.8 Nutrition Education: Implementation of Dietary Goals

XXXIII. Each member country should consider implementation of nutrition education and nutrition intervention programmes to promote health and operational readiness. The programmes should include menu modification, recipe changes, training the cooks as well as educating the diners in good nutritional habits.

XXXIV. Intervention programmes should be tailored to national problems and should include an evaluation component to determine cost effectiveness.

0.4 MILITARY IMPLICATIONS

XXXV. Most member countries have already modified or have made plans to modify the nutritional content of their packaged combat rations to comply with the agreed nutritional guidelines provided by RSG-8 to NATO STANAG 2937. Progress is also being made to incorporate the agreed Guidelines for a Healthful Diet in garrison menu planning and nutritional education programmes. Several member countries have also expanded their combat and garrison ration research, development, test and evaluation programmes to include the measurement of soldier opinion, acceptability, nutrient consumption, nutritional status and performance assessment utilizing agreed methodologies described in this report. These accomplishments reflect the follow-on activities of RSG-8 members within their respective countries.

XXXVI. It should be emphasised that the formation and ongoing activities of RSG-8 had a key role in stimulating a revitalisation of military nutrition research within several member countries. This fact is documented in the numerous research projects conducted since the inception of RSG-8 which are summarised and referenced in this report or published as a Proceedings, in three issues, of the Netherlands Military Medical Journal, volume 37: April, June and November 1984. The formation of RSG-8 resulted in the cross fertilization of research ideas and methodologies and

For instance, the assignment of a military scientist from the United Kingdom to conduct nutrition research at a military laboratory in the United States. It is recommended that further scientific exchange and research cooperation between NATO members be favourably considered.

XXXVII. Further research and cooperation between member countries is required to develop new nutritional technologies and feeding strategies to enhance and sustain physical, mental and overall military performance in the demanding operational scenarios of the future battlefield. For example, the unresolved issue in this report (because of insufficient data) was the nutritional guidelines for feeding and hydrating military personnel under NBC warfare conditions. The RSG-8 members identified a need for a follow-on workshop to address this major unresolved issue.

XXXVIII. The primary military implication of the adoption of the nutritional guidelines and recommendations of RSG-8 will be to the men and women of our military forces. They will be provided with a more acceptable and nutritious diet that will promote their health, enhance their readiness, sustain their combat performance and speed their recovery from injury or disease. All member nations are urged to fulfill their obligations in this regard.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

1.1.1 Initial Stimulus

1. The initial stimulus for the formation of RSG-8 was the "Report of the NATO Sub-Committee on Nutritional Aspects of Military Feeding" provided to The General Medical Working Party of the Military Agency for Standardization (MAS) by letter MAS (Army)(75)41 dated 21 Jan 1975. This report of a meeting held in London in September 1974 recognized a need for more information on the nutritional research conducted by each of the NATO countries. This meeting was chaired by COL J. P. Crowdy, UK, with delegates attending from BE, CA, FRG, NL, NO, UK and US.

2. In response to an inquiry from Panel VIII (DS/DR(75)417 dated 2 Oct 1975), the Army Board, MAS provided (MAS (Army)(76)43 dated 26 Jan 1976) a list of nutrition research topics for which there was a need for data or initiation of cooperative research. The topics proposed were:

(a) Energy Expenditure Further information is needed about the energy expenditure of troops involved in prolonged strenuous activity in climatic extremes. A collaborative project to develop and standardize a reliable predictive method of energy expenditure measurement would be extremely valuable and worthwhile.

(b) Low Energy Diets More research information is needed on the effects of low energy diets (of the order of 7-8 MJ per day creating an energy deficit of at least 4 MJ per day) on military efficiency with particular reference to performance of detailed and difficult mental tasks.

(c) Iron Intake and Requirements With the increasing number of women in the Defence Services (of all member nations), the dual questions of desirable hemoglobin level and the associated iron intake merit further investigation.

(d) Obesity Perhaps the most urgent of all topics for further collaborative research is that into the increasing problem of obesity in otherwise fit young soldiers. Research into the relationship between obesity and military performance should precede agreement on the desirable criteria for body composition and standards for assessment of obesity. More information (with a view to subsequent standardization) is also needed on the best methods for measurement of obesity.

1.1.2 Formulation of Exploratory Group

3. During their April 1978 meeting, Panel VIII requested the formation of an Exploratory Group (EG) on Nutritional Aspects of Military Feeding under the chairmanship of Brigadier J. P. Crowdy, UK. Subsequently, at the June 1979 meeting, Panel VIII requested that draft Terms Of Reference (TOR) for a new RSG on Nutritional Aspects of Military Feeding. Brigadier Crowdy circulated a draft TOR with prospective EG members, incorporated comments, and forwarded these to Panel VIII. At their June 1980 meeting, Panel 8 requested that the TOR be modified to prevent overlap with the work of RSG-4 (Physical Fitness) and to concentrate more on operational feeding aspects.

4. The UK hosted the Exploratory Group Meeting at the Royal Army Medical College, London, during 14-16 Oct 1980. Attendees included 12 representatives from 6 countries (CA, FRG, GR, NL, UK and US). Significant accomplishments included:

(a) Recommendation to establish a RSG.

(b) Developed agreed Terms of Reference.

(c) 10 Scientific presentations

(d) Recognition that there was essentially no ongoing military nutrition research in member countries and that this area needed immediate attention by the RSG membership.

(e) Recognition of need for RSG-8 members to comment on the draft STANAG 2937-Standardization of Combat Rations.

1.1.3 Establishment of RSG-8

5. At the November 1981 meeting, Panel VIII formally established the RSG-8 Nutritional Aspects of Military feeding and approved the TOR developed by the EG at the October 1980 meeting in London. The agreed TOR were as follows:

(a) Main Objectives

(i) To promote active collaboration on research topics for the establishment of nutritional requirements, in their broadest sense and taking into account nutritional status, for both operational and peace-time conditions.

(ii) To foster agreed research methods to meet these needs.

(b) Technical Objectives

(i) Nutritional and Operational Performance Effectiveness. To study the importance of diet, including water, for the sustenance of military personnel under all operational conditions, such as sleep deprivation, climatic extremes, atmospheric pressure variations, time-zone transportation, sustained operations, survival situations and NBC warfare.

(ii) Improvement of Nutritional Status. To develop common methods of measurement and assessment for nutritional status and obesity with the ultimate aim of agreement on desirable body composition standards for military personnel.

(iii) Prevention of Disease and Promotion of Health. To study nutritional factors in the causation of diseases of military importance with the objective of developing an agreed military policy on good dietary practices for all members of the Armed Services.

1.2 HISTORICAL ACCOUNT OF RSG-8 ACTIVITIES

1.2.1 First Meeting

6. The US hosted the first meeting of RSG-8 at the U.S. Army Natick Research and Development Laboratories, Natick, MA, on 3-7 May 1982. This was a joint meeting with RSG-4 who met at the U.S. Army Research Institute of Environmental Medicine also at Natick, MA. This meeting was attended by 13 representatives from 7 countries (BE, CA, FR, FRG, NL, UK and US). Significant accomplishments included:

(a) Nutritional guidelines for the draft STANAG 2937 agreed and forwarded to MOD Q (Plans).

(b) Workshops were held on the following topics:

- (i) Dietary and Food Acceptance Methodologies
- (ii) Operational Rations and Performance
- (iii) Dietary Goals for Military Personnel
- (iv) Strategies to Improve Dietary Habits of Military Personnel
- (v) Body Composition Methodologies (Joint Session with RSG-4).

(c) Specific agreements resulting from the workshops included:

(i) Agreed dietary guidelines for general military populations
(ii) All body composition studies shall include the Durnin-Womersley four skinfold measurements
(iii) Identified the following areas of research requiring further investigation:

- Need to improve laboratory methods to predict food consumption in the field.

- What should be the nutrient content of a liquid ration for feeding in a chemical environment?

- How long will troops consume packaged operational rations as the primary source of food? Which foods will be rejected most often by most troops? What is the acceptance of food items which are primary carriers of vitamin and mineral fortification?

- How important are hot meals in the field on food intake, food preference, morale and attitude? Can troops be trained to accept cold and limited variety rations for prolonged periods?

- Are there dietary supplement, frequency of feeding strategies, etc., that will minimize projected performance decrements during sustained operations?

- Do troops in the Arctic actually expend more energy, and therefore, is an Arctic supplement required?

- Does leadership capability falter during short-term caloric deficits?

- Is constipation a significant problem with prolonged feeding of operational rations? Should dietary fibre be added to operational rations.

- Dietary guidance - further information needed on saturated vs unsaturated fat content, salt, and essential hypertension, and effectiveness of behavioural techniques for dietary and lifestyle change.

1.2.2 Second Meeting

7. The Netherlands hosted the second meeting of RSG-8 at CIVO Institutes TNO, Zeist during 17-21 October 1983. Attendees included 14 representatives from 8 countries (BE, CA, DK, FR, FRG, GR, UK and US). In addition, 13 guest speakers from 3 countries presented research papers at this meeting. Significant accomplishments included:

(a) Particularly noteworthy were scientific presentations of military nutrition research initiated since the formation of EG in member countries including BE, CA, FRG, NL and US.

(b) A total of 23 scientific presentations were published as the Proceedings of the RSG-8 meeting in three issues of the Netherlands Military Medical Journal, Vol 37: April, June and November, 1984.

(c) Further revisions of STANAG 2937 were developed and forwarded to MAS.

(d) LTC David Schnakenberg, US, was nominated to replace the retiring MG J.P. Crowdy as RSG-8 Chairman.

1.2.3 Third Meeting

8. The FRG hosted the third meeting of RSG-8 at the Federal Armed Forces Medical College in Munich during 10-15 June 1985. Attendees included 12 representatives from 7 countries (CA, DK, FRG, NL, NO, UK and US). In addition, six guest speakers presented results of ongoing nutrition research in the FRG. Significant accomplishments included:

(a) The CA, FRG, NL, UK and US representatives reported on the results or plans for:

- (i) Operational ration trials,
- (ii) Garrison feeding evaluations,
- (iii) Carbohydrate supplementation to extend performance
- (iv) Longitudinal surveys of nutritional status and physical fitness
- (v) Nutritional health promotion programs

(b) The members agreed to an outline and writing assignment for the draft final report for RSG-8.

(c) The STANAG 2937 sections on survival rations were again reviewed and revisions provided to MAS.

1.2.4 Fourth Meeting

9. Canada hosted the fourth meeting of RSG-8 at the Defence and Civil Institute for Environmental Medicine at Toronto during 6-10 October 1986. A total of 11 representatives from 8 member countries (BE, CA, DK, FRG, NL, NO, UK and US) made significant contributions to describe ongoing nutritional developments in their respective countries including:

(a) Assessment of prevalence of coronary risk factors and physical fitness in Belgium and Netherlands Army personnel.

(b) Influence of carbohydrate supplements on performance in cold and high altitude environments.

(c) Nutritional initiatives to reduce fat content of garrison and shipboard menus in Denmark, Norway and United States.

(d) Development of plans for postoperative alimentation of casualties in Federal Republic of Germany.

(e) Nutritional evaluation of field rations in United States.

10. The members reviewed the draft chapters for the final RSG-8 report and made suggested revisions for the final outline of the report.

1.2.5 Fifth Meeting

11. Belgium hosted the fifth meeting of RSG-8 at the Military Hospital in Brussels during 6-10 April 1987. A total of 11 representatives from 8 member countries (BE, CA, DK, FRG, NL, NO, UK and US) summarized the significant military nutrition activities ongoing in their respective countries including:

(a) Longitudinal studies of the changes in body composition, coronary risk factors and physical fitness of NCO and Officer personnel in Belgium, the Netherlands and the United Kingdom.

(b) Plans for evaluating nutrient solutions for personnel wearing protective clothing systems in the Federal Republic of Germany, the United States and the Netherlands.

(c) Progress in the implementation of nutrition initiatives to reduce the fat content of garrison and shipboard feeding systems in Denmark, Norway and the United States.

(d) Nutritional evaluation of field rations for personnel engaged in sustained heavy physical activity in Canada and the United States.

(e) Nutritional health promotion activities in Canada, United States and the United Kingdom.

12. The members presented and reviewed draft chapters for the final RSG-8 report. Discussions resulted in some modifications to chapter outlines to place even more emphasis on the importance of nutrition to the performance of critical military tasks.

1.2.6 Sixth Meeting

13. The United States hosted the sixth meeting of RSG-8 at the U.S. Army Research Institute of Environmental Medicine in Natick, MA, during 9-13 November 1987. A total of 11 representatives from 8 countries (BE, CA, DK,

FRG, NL, NO, UK and US) attended. In addition to national updates on the results and progress of on-going research, the emphasis of this meeting centred on the Final Report. Drafts, previously circulated, were reviewed and amended in readiness for the Report.

1.3 OBJECTIVES OF THE FINAL REPORT

14. There was agreement among the members that it was not appropriate for RSG-8 to attempt to write a comprehensive textbook on Nutrition and its relation to health, fitness and performance. However, it was agreed that there was a need to briefly summarize what is known about the nutrient and water requirements of military personnel to maintain their health, promote physical fitness, support development of muscle strength and endurance during training, maintain optimal body composition, sustain and enhance mental, physical and military task performance during sustained operations in all environmental extremes. It was also agreed that there was a need to briefly summarize and review various methodologies that have been used or could be used to measure acceptability and consumption of military rations, assess the nutritional status and body composition of military personnel and to discuss various materials and procedures that have been used to enhance the nutritional knowledge and awareness of individuals, commanders, food service and medical personnel. It was also agreed that there was a need to compile a comprehensive description and nutritional composition of the various rations in use by the various NATO countries.

15. The information to be provided will be drawn from the published literature with particular emphasis from those studies conducted with military populations by the member countries. It should be recognized that major proportions of the data presented are drawn from studies conducted by member countries since 1982 when the RSG-8 held its first meeting.

16. The report contains a summary of the key findings, agreed nutritional criteria for operational rations and garrison feeding, methodologies for nutritional evaluation of military rations, and feeding systems. Areas of inadequate information will be identified and recommendations for further research and study will be provided.

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CHAPTER 2

NUTRIENT REQUIREMENTS AND RECOMMENDATIONS FOR MILITARY PERSONNEL

2.1 INTRODUCTION

17. This chapter will consider the contribution of different nutrients to health, review the requirements for different nutrients and make recommendations on recommended dietary intakes and allowances on which military feeding should be based.

18. The objectives in establishing dietary requirements have been clearly defined (1), namely a) to provide a baseline against which dietary intake can be compared and b) to provide guidelines to caterers and food planners. In the military scenario this latter objective would apply to food planning both in and out of barracks.

19. Calculation of the body's requirement for a particular nutrient can be approached in a number a ways:

(a) **The Epidemiological Approach** - Intakes of the nutrient are recorded from a healthy group of people and from a group where there is clinical evidence of a deficiency.

(b) **The Experimental Approach** - Diets containing variably reduced amounts of an essential nutrient are fed to individuals until a deficiency state can be demonstrated.

(c) **The Estimation of Tissue Reserves of Nutrients** - This involves making estimates of blood, urine or tissue concentrations of individual nutrients.

20. From the above methods, an assessment of the minimal requirement for a particular nutrient can be made, if necessary for a particular group of people (for example, men versus women, active versus sedentary). Having established the minimum daily requirement, an assessment of the recommended dietary intake needs to be made. This is generally achieved by adding to the minimum daily requirement two standard deviations plus a small margin for error. The resulting recommendation is likely to cover most if not all of the population concerned.

21. However, the lack of knowledge in some areas has led to the committees involved in the formulation of dietary recommendations to be cautious. In the United Kingdom, civilian Recommended Dietary Intakes (RDI) are aimed at groups, not individuals; nevertheless they do include a margin of error in an attempt to take account of physiological differences between individuals.

22. In the United States, Recommended Dietary Allowances (RDA) are designed to provide levels of intake of essential nutrients considered to

be adequate to meet known nutritional needs of practically all healthy persons. - Committee on Dietary Allowances (2). Neither RDAs nor RDIs, however, allow for alterations in requirement caused by other factors such as illness, trauma, unusual stress or major weight change.

23. NATO Armed Forces, in formulating recommendations, generally follow their own country's civilian guidelines. For example, the United States prescribes Military Recommended Dietary Allowances (MRDA), based on the RDAs, and advises that nutrient losses during food processing and cooking must be considered when nutrient composition tables are used to compare menus or rations to the MRDAs (3). Most NATO countries make recommendations or allowances for increased levels of physical activity especially during cold weather operations.

24. In the following sections, consideration will be given to the various constituents of the diet.

2.2 ENERGY (Calories/Megajoules)

2.2.1 Introduction

25. An inadequate supply of energy in the diet relative to energy expenditure will lead to body weight loss as stored energy is metabolized. Conversely, excess dietary energy relative to expenditure will ultimately lead to obesity.

26. A detailed description of the release and utilization of energy by the body from metabolizable fuel supplied in the diet is outside the scope of this document. Nevertheless a brief overview may help the reader.

27. The SI unit for energy is the Joule usually expressed as either Megajoules (MJ) or Kilojoules (kJ), but the classical unit Kilocalories (kcal) is still very much in use. Where possible in this report, both units are used. The conversion between the units is:

$$1000 \text{ kcal} = 4184 \text{ kJ} = 4.2 \text{ MJ}$$

28. Energy can be derived from carbohydrate, fat, protein and other organic chemicals such as alcohol, fatty acids and glycerol. The approximate energy value of the three major fuels are:

Fat	9 kcal/g = 38 kJ/g
Carbohydrate	4 kcal/g = 17 kJ/g
Protein	4 kcal/g = 17 kJ/g

29. The proportion of the energy derived from each of these materials is dependent upon their relative proportions in the diet. When consumed in excessive quantities fuels can be stored and utilized when energy intake is low. Large quantities of fat can be stored by the body, but only

relatively small quantities of carbohydrate (as glycogen in the muscles and liver). Protein is a rather a special case in that, although when fed in excess it is broken down and utilized for energy production or converted to fat and stored, body protein (chiefly muscle protein) can be broken down to provide energy when food intake is reduced (for example, in starvation). Carbohydrate metabolism is more efficient than fat metabolism but due to the small body stores, reserves can be depleted within one to two hours of heavy physical work. The possible beneficial effects of high carbohydrate diets (with particular reference to physical performance) and the dangers associated with high fat diets (with particular reference to coronary and arterial disease) are considered in other chapters.

30. Energy requirements are affected by a number of factors, those which appear to have the greatest importance in a military population are listed in Table 2.1.

Table 2.1 Major Factors Influencing Energy Requirements

INTERNAL FACTORS	EXTERNAL FACTORS
Physiological	Environmental
Age	Climate
Sex	Altitude
Weight	Terrain
Muscle Mass	
Fitness	Physical
Arousal level (sleep)	Load carrying
Acclimatization	Efficiency
	Work/rest cycles
Psychological	Clothing
Emotional condition	
Stress	
CLINICAL FACTORS	
Disease	
Fever	
Trauma	
Burns	

31. Calculating the energy requirements for military groups has occupied a considerable amount of research activity, but despite this effort, it is still not possible to quantify energy requirements with any degree of certainty. Due to the variability in factors presented in Table 2.1, detailed requirements remain unknown (4) as only broad requirements for different groups have been ascertained.

2.2.2 The Effects of Age

32. The energy requirements during adolescence and the period of maximum growth are generally higher than at any other time of life. These requirements decrease with age due to a number of factors such as activity, body composition and resting metabolism, this last factor decreasing by some two percent per decade (5). In an attempt to allow for this, the FAO/WHO (6) recommend that from a "full" energy intake at age 20 to 39, both men and women should suffer a 5% decrease per decade up to the age of 59. In the USA (2) a reduction of 200 kcal/day is applied to personnel over 23. The US forces, however, consider that the changes within the 17 to 50 military age range, for similar levels of physical activity, are sufficiently small to be ignored.

2.2.3 The Effects of Gender of Personnel

33. Women, generally have a lower energy requirement than men. This is due to their relatively smaller muscle mass. Allowances are made for female personnel in all the civilian dietary recommendations, and those NATO nations which recruit female personnel and use civilian recommendations have adopted these. Only in the USA military are recommendations specifically made for female personnel (3). These will be presented, alongside the male recommendations, later in this chapter.

2.2.4 The Effects of Body Size

34. The energy expenditure involved in moving a large body is slightly greater than that required to move a small body. Additionally, as non-fatty tissue has a higher metabolic rate than fatty tissue, personnel with a large muscle mass will tend to have a higher resting metabolic rate. Allowances for body size are made in some of the civilian tables of recommended intake. In the military, although no allowances for variation in body size and composition are made in any nutritional recommendations, allowances are often made on the basis of a "standard man". In the USA, allowances have been calculated on the basis of a standard 70 kg man. If a figure of 72.5 kg is chosen over 3/4 of the male population of the UK would be covered (7).

2.2.5 Psychological Effects

35. Psychological stress and other emotional conditions may affect energy expenditure. This may be a function of physiological changes; for example a rise in catecholamine levels during fright leading to an increased metabolic rate, or a function of behavioral changes leading to alterations in energy expenditure. These factors are, however, difficult to quantify as they cannot be readily or reliably induced in the laboratory.

2.2.6 The Effects of Climate

36. Naked man is able to thermoregulate by changes in peripheral circulation over a relatively small range of ambient temperatures. As the temperature falls below this range shivering increases heat production and hence energy expenditure; conversely as the temperature rises, sweating increases heat loss from the body. This may be associated with an increased heart rate and an increased energy expenditure.

37. When appropriately clothed, however, the situation is more complex. It has been suggested (8) that energy requirements increase in men working at low mean ambient temperatures. This suggestion was supported with data collected from physically fit soldiers serving in various climatic conditions (9). Whether the increase is a direct result of an increased metabolic rate induced to maintain body temperature constant, or an indirect result of the hobbling effect of heavy, cold weatner clothing and equipment has been the subject of a number of investigations.

38. Iampietro et al. (10) reported that, when the effects of clothing and activity are removed, and correcting for body weight loss, for every 1^{o}C fall in the mean ambient temperature there is a corresponding increase in energy expenditure of 10 kcal per day; a figure of a similar magnitude to the 20 kcal per day suggested by Johnson & Kark (9). These are relatively small increases, as it has been shown (11) that when desert clothing is changed to temperate clothing, or temperate clothing changed for arctic clothing, energy output is in each case increased by some 5% (equivalent to some 200 kcal per day). Provided that individuals are adequately clothed, the additional energy requirements for cold weather operations appear to be in the region of 2 - 5% (12).

39. A number of countries recommend and make provision for an increased dietary intake of nutrients in cold environments. Some examples are given in Table 2.2.

Table 2.2 Countries Recommending an Increase in Nutrient Intake for Military Personnel in Cold Environments

Country	Recommendation (per day)
Australia	Basic Cold Weather Supplement: Fresh Milk 85 g 55 kcal Sugar 30 g 118 kcal Drinking Chocolate 30 g 110 kcal Total 283 kcal
Canada	Arctic Supplement: Drinking chocolate 87 g 300 kcal Fruit Cake 232 g 512 kcal Total 812 kcal
Finland	10% Increase in Energy Consumption
Norway	10% Increase in Energy Consumption
United States	5% Increase in Garrison Troops where the mean ambient temperature is less than 14°C. Provide 4500 kcal for manoeuvres with heavy gear over snow covered terrain
United Kingdom	Hot Drink Supplement: (Issued when exceptional conditions prevail over a long period). Tea 4 g (or Coffee 6 g or Cocoa 6 g) Sugar 14 g Fresh Milk 28 ml (or Canned 9 g or Dried 7 g) Alternative: Rum 28 ml Arctic Supplement: A cash allowance equal to approximately 20 per cent of the food value used for local purchase when fresh rations are consumed (intended primarily for exercises in Norway).

40. Evidence that energy expenditure increases in a hot environment is provided by Consolazio et al. (13). They showed that for men working in two climates, 70°F (21.1°C) and 100°F (37.7°C), metabolic rate was 11.7% higher at rest, 13.6% higher during moderate activity and 11.7% higher during high activity in the hotter of the two climates. The main effect of hot environments is to increase water requirements. Thus, whereas few countries recommend specific increases in dietary intake, a number provide fruit flavorings to encourage fluid intake. Those countries providing hot weather supplements are shown in Table 2.3.

Table 2.3 Countries Recommending an Increase in Nutrient Intake for Military Personnel in Hot Environments

Country	Recommendation (per day)		
Australia	Basic Hot Environment Supplement		
		Fresh Fruit	390 g
		Sugar	110 g
		Tea	12.5 g
		Salt	20 g
Canada	Tropical Ration Supplement		
		Fruit Beverage powder to make	6[illegible] ml
South Africa	Hot Weather Supplement		
		Concentrated Fruit Juice:	
		September to April	60 ml
		Heat stress risk areas	150 ml
		Operational Areas SW Africa	150 ml
United Kingdom	Hot Weather Supplement		
		Lemonade/orangeade powder	
		Concentrated Powder	113 g
	Ice for Drinking water: Issued during hot weather when refrigerators or water coolers are not available. A scaled issue of 2-3 lbs per man per day.		
United States	0.7% increase in calorific allowance for every degree increase in the ambient temperature above 30°C.		

2.2.7. The Effects of Altitude

41. Evidence for an increased energy requirement at high altitude is far from conclusive. Consolazio et al. (14) could not demonstrate an increased energy requirement at 3475 m, although, at 4300 m oxygen usage was increased indicating that energy requirements may be enhanced. On the other hand, the oxygen consumption of soldiers, both resting and working, were similar at 4300 m and at sea level (15). Studies of Indian troops engaged on normal duties (16) found that energy expenditure was approximately 1000 kcal greater at altitudes between 3658 and 4572 m than the 3200 kcal required at sea level, but attributed this to the weight of clothing and the steepness of the terrain.

42. Anorexia is a phenomenon often observed on abrupt exposure to altitude and probably associated with the other usual signs and symptoms (hypoxia, hypocapnia, hyperventilation, headaches, nausea and difficulty in sleeping). In studies where an increased energy requirement was complicated by a negative calorific balance (12), additional carbohydrate was found to reduce symptoms and increase performance. This is probably due to the fact than carbohydrates yield 40% more carbon dioxide than fats, thus reducing the hypocapnia, and 3.7 and 12.7% more energy per litre of oxygen than fat and protein, advantageous when hypoxia may be limiting performance.

2.2.8 Physical Work Patterns

43. Clearly a man regularly doing a lot of hard physical work expends more energy than a man doing very little and thus requires more calories in his diet. It is conventional to divide personnel into three groups, namely Sedentary, Moderately Active and Very Active. For the average 70 kg male energy requirements have been variously estimated as follows (Table 2.4). The figure for females assumes a sedentary to moderately active job.

Table 2.4 Daily Energy Requirements for Different Activities

Activity	Allowance	(Range)
Males		
Sedentary (Office workers, Staff appointments)	2800 kcal 11.7 MJ	(2400-3200)
Moderately Active (Training Establishments, Workshops)	3200 kcal 13.4 MJ	(2800-3600)
Very Active (Recruit training, Field units)	3600 kcal 15.1 MJ	(3200-4000)*
Females	2400 kcal 10.0 MJ	(2000-2800)

* Energy expenditures of over 5000 kcal have been estimated under certain extreme circumstances.

2.2.9 Acute Requirements

44. In certain circumstances for example during a long forced march, average weekly or monthly energy expenditure will underestimate the energy requirements of a particular task or activity.

45. Load carrying is a normal feature of military training and operations, and there is close agreement between energy expenditure and the weight of loads up to 70 kg providing the load is well balanced and close to the centre of the body (17,18). Although standing with various loads does not significantly effect energy expenditure, it varies with the weight of the load, walking speed and the gradient and type of the terrain (19).

46. Various attempts have been made to produce equations to predict energy requirements from factors such as load carried, type of terrain and speed over the ground. The most widely used are those of Givoni & Goldman (20). The equations below give the calculation of energy expenditure (requirements) during walking/marching.

$$M = N*(W+L)*[2.3+0.32*(V-2.5)^{1.65}+G*(0.2+0.07*(V-2.5))]$$

where N = Terrain Factor. (see below)
W = Body Weight (kg). (Assume 70)
L = Weight Carried (kg).
V = Walking Speed (kph).
G = Slope (Grade %).
M = Metabolic Rate (kcal/hr).

Terrain Factors:

Terrain	Factor
Treadmill	1.0
Tarmacadam Surface	1.0
Dirt Road	1.1
Light Brush	1.2
Heavy Brush	1.5
Swampy Bog	1.8
Sand Dunes (Firm Sand)	1.8
Hard Packed Snow	
No footprint Depression	1.3
For each cm Depression	+0.082

2.3 FAT AND CARBOHYDRATE

47. The total amounts of fat and carbohydrate consumed in the diet (with a small contribution from protein) are the determinants of energy supply. The question then arises as to what are the ideal relative proportions of these energy sources in a healthy diet. A fundamental change in nutrition education policy has occurred in the last decade. The following points, many taken from NACNE (21), should be stressed when recommendations as to the calorie make up of a diet are formulated:

48. Carbohydrates are not particularly fattening components of the diet, whereas fats are. High intakes of fat (particularly saturated fat) enhance the risk of coronary heart disease. Whereas some of the mediterranean countries have diets very low in fat (and a population with a low incidence of heart disease), many of the other member nations of NATO have diets with a high fat content (and a population with a high incidence of heart disease). A reduction in the contribution of fat to total energy intake is advocated for these latter nations. This may be achievable by increasing the intake of cereals and bread as well as vegetables and fruit and reducing the intake of foods rich in fats, for example, meat products, dairy products and fried foods.

49. The body is unable to synthesize certain unsaturated fatty acids. These are therefore, like vitamins, required in the diet. There is also some evidence that a higher ratio of unsaturated fat to saturated fat in the diet can promote health. The ideal intake of unsaturated fat has not, however, been resolved, although for polyunsaturated fats, a minimum figure of 3% of calorie intake is suggested. In the UK dairy fat accounts for about a third of total fat intake, and meat fat about 27% (22). Increasing the intake of cereals, beans and other vegetables at the expense of these animal products will lead to an increase in both the absolute and relative intakes of unsaturated fat.

50. The addition of extra unsaturated fats to a diet already too high in total fats is not recommended. The replacement of some saturated fat by unsaturated fat may be of benefit, but the ideal approach would be a reduction in total fat by a reduction of saturated fat.

51. Recommended dietary intakes of different nutrients are not considered to apply to individuals but to groups. Thus, by providing enough to cover the needs of the large majority of the group, those individuals with a requirement at the lowest end of the normal range will be over supplied. This is acceptable if it is known that there is no danger associated with an excessive intake of a particular nutrient. Unfortunately this is not the case, particularly with regard to fat intake. However, individual susceptibility to constituents in the diet appears to vary widely. To minimize the incidence of illness and death, nutritional advice should aim to prescribe a diet with the least risk to the population as a whole rather than concentrating on the extremes of the population.

52. A balanced diet should be more than just a selection of foods needed to avoid vitamin, mineral or protein deficiency. It should also consider the relative proportions of fat and carbohydrate.

53. The concept of food groups should be applied with care. Considering 'protein foods' as good for growth, 'energy foods' for physical work and 'protective foods' to prevent vitamin and mineral deficiencies can be misleading. For example, many cheeses should be considered 'high fat foods' and not given the accolade 'protein food'.

2.4 PROTEIN

54. A lack of dietary protein can cause kwashiorkor and, with limited calories, marasmus. These "famine" diseases are unlikely to be seen in western civilizations, a dietary excess is more probable. Dietary protein in excess to requirements is broken down to provide energy or stored as fat. The suggestion that very active personnel require higher levels of protein intake is not supported unless active muscle building is in progress. Although protein turnover may increase during very hard physical work protein loss from the body does not seem to increase significantly. Similarly, there is no evidence to suggest that physical performance is enhanced by increasing protein intake from 53 to 106 or even to 168 g/day (23).

55. The nutritive value of a protein depends on the relationship of the amino acids present in the molecule to those required by the body. If a protein is deficient in one amino acid, however much is eaten, nitrogen balance cannot be maintained. However, if another protein containing sufficient quantities of this "limiting" amino acid is present in the diet, equilibrium can be maintained. The amino acids which are most likely to be limiting are tryptophan, lysine, methionine and cysteine. For example, bread is low in lysine, but pulses have a high level of this amino acid. Thus, a combination of the two will balance the deficiency in either one.

56. Historically, protein has been divided into 1st class (animal) and 2nd class (plant). This division is no longer valid, as rice and soya bean protein is little inferior to meat protein, and a diet containing a good balance of grain and pulse protein can well be superior to a high meat protein diet.

57. The minimum level of protein intake recommended by the FAO/WHO in 1974 (6) was 0.57 g/kg body weight per day provided that total energy requirements were fully met. This was subsequently amended (24) to 0.7 g/kg body weight, a value now thought to correspond to the lower end of the safe range of intake. Recommendations in the United States (2) are for 0.8 g/kg of body weight.

58. The advice provided by the UK DHSS (25) centres on the assumption that when a free selection of food is economically available, diets will naturally be chosen to contain 10 to 11% protein. Diets containing less than these amounts would generally be considered unpalatable. On the other hand, no evidence exists suggesting that slight over consumption would be harmful. On the basis of 10% of energy intake, this figure is 80 g per day.

59. The US military recommended allowance of 100 g per day for a moderately active soldier is designed to reflect usual intakes and to ensure a high level of palatability and acceptability (3).

60. The recommendations given by each NATO nation (where available) for protein intake are presented in Table 2.9.

2.5 DIETARY FIBRE

61. It is really only in the last decade that the importance of an adequate level of fibre in the diet has been recognized (26). This material is mainly composed of indigestible polysaccharide carbohydrates such as cellulose. It has a marked effect on faecal weight, dilutes intestinal contents and shortens gut transit times. There is good evidence for a link between dietary fibre deficiency and a number of medical conditions, particularly large bowel diseases such as constipation, diverticulosis, irritable bowel syndrome and colon cancer.

62. An intake of 30 g of dietary fibre per day would seem to be a reasonable goal for those nations with a currently low supply.

2.6 VITAMINS

63. Vitamins are defined as chemically unrelated substances that, in small amounts, are essential to the maintenance of normal metabolic functions. They are not synthesized in the body either at all or in sufficient quantities and must therefore be supplied in the diet.

64. There are two families of vitamins, the fat soluble and water soluble vitamins. Fat soluble vitamins (A, D, E & K) can be stored in the body, mainly in the liver but also in fat. A daily supply is therefore not necessary. As they are stored, excess intakes (particular of vitamins A & D) can be toxic. Water soluble vitamins (the B complex and vitamin C) are not stored in the body to any significant degree. They therefore need to be supplied on a regular, ideally daily, basis. If taken in excess they are excreted in the urine. Most are vital cofactors for the metabolism of fats and carbohydrates.

65. The following sections discuss the requirement for each Vitamin in turn. Table 2.5 gives recommended daily intakes (2). Not all NATO nations make recommendations on the intake of all vitamins for their military populations. A listing of the available information from each NATO nation is given in Table 2.9.

Water Soluble Vitamins

2.6.1 Vitamin B1 (Thiamin)

66. This vitamin is an essential cofactor in the conversion of pyruvate to acetyl coenzyme A, the basic fuel in the Krebs cycle for the production of adenosine triphosphate (ATP). The requirement for thiamin, therefore, is closely linked to the intake of carbohydrate. Diets which contain more than 0.3 mg/1000 kcal have been shown to prevent beriberi whilst at intakes above 0.33 mg/1000 kcal, progressively large quantities are excreted in the urine suggesting a dietary excess (6). Symptoms of deficiency include reduced work output and fatigue, anorexia and irritability, all readily reversed after yeast supplement. A daily intake

of 0.14 mg has been shown to maintain maximum work capacity for 7 weeks, but 0.2 mg/day inadequate for 19 weeks. Good sources of this vitamin are yeast, pork, liver, kidney and wholemeal cereals. Thiamine is partly destroyed during cooking.

67. Recommended allowances are in the range 0.4 mg/1000 kcal (6, 27, 25) to 0.5 mg/1000 kcal (2). The recommended intake for moderately active servicemen is 1.6 mg per day.

2.6.2 Vitamin B2 (Riboflavin)

68. Riboflavin is the precursor of flavin adenine dinucleotide (FAD), a cofactor in energy metabolism. Evidence of deficiency disease has not been found in diets containing less than 0.25 mg/1000 kcal and significant amounts do not appear in the urine until this intake has doubled (FAO/WHO 1974). The symptoms of deficiency are lesions of the skin and gut. The vitamin is fairly stable to cooking but is destroyed by light. It is found in milk, liver, kidneys, heart and green vegetables.

69. In order to provide a reasonable safety margin for individual variability, the recommended allowances for a number of countries range from 0.5 mg - Canada (27), 0.6 mg - USA (2) to 1 mg - UK (25), all values being per 1000 kcal of energy intake. The female requirement may be raised during heavy physical work. The recommended intake for moderately active servicemen is 1.9 mg per day.

2.6.3 Vitamin B3 (Niacin, Nicotinic Acid)

70. Nicotinic acid is the precursor of nicotinamide adenine dineuceotide (NAD), another cofactor in energy metabolism. The minimum requirement for preventing pellagra is 4.4 mg/1000 kcal and significant amounts appear in the urine at intakes above 5.5 mg/1000 kcal (6).

71. Niacin can be synthesized in the body from the essential amino acid tryptophan in the ratio of 1 mg of niacin per 60 mg of tryptophan. To take account of this, intakes of this vitamin are generally expressed as Niacin Equivalents (NE), where 1 mg NE = 1 mg Niacin = 60 mg tryptophan. Deficiency states manifest themselves as skin and gut lesions and emotional disturbances. Good sources are yeast, liver, lean meat, ground nuts and legumes.

72. In order to provide a reasonable safety margin for individual variability, the recommended allowances for a number of countries range from 6.6 mg - USA (2) to 7.2 mg - Canada (27) to 11.3 mg - UK (25), all values being Niacin Equivalents per 1000 kcal of energy intake. The recommended intake for moderately active servicemen is 21 mg NE per day.

2.6.4 Vitamin B6 (Pyridoxine)

73. This vitamin comprises a group of three pyridines acting in a variety of enzyme systems associated with nitrogen metabolism. Deficiency states are rare as this vitamin is found in practically all vegetable and animal foodstuffs. Good sources of this vitamin are yeast, liver and wholemeal cereals.

74. Recommended daily intakes are given in Table 2.5.

2.6.5 Pantothenic Acid

75. This vitamin in its conjugated form is Coenzyme A, an intermediate in fat and carbohydrate metabolism. It is found in all plant and animal tissues and deficiency states are unlikely.

76. Recommended daily intakes are given in Table 2.5.

2.6.6 Folic Acid (Folacin)

77. This vitamin has an essential role in protein metabolism and in the synthesis of DNA and RNA. It is also essential for normal red blood cell production. The main symptoms of deficiency are alterations in blood and bone marrow function and gastrointestinal disorders. Folic acid is found in offal, dark green vegetables and yeast. Folic acid is very sensitive to heat and 50 to 95% of the activity is destroyed by cooking.

78. Recommended daily intakes are given in Table 2.5.

2.6.7 Vitamin B12 (Cyanocobalamin)

79. This vitamin, known as the anti-pernicious anaemia factor, is needed for the normal functioning of the central nervous system and for haemoglobin production. The major symptom of deficiency is anaemia. The major dietary sources are liver, kidney, meat and milk. Cooking destroys up to 30% of the vitamin.

80. Recommended daily intakes are given in Table 2.5.

2.6.8 Biotin

81. This vitamin is required for the transfer of CO_2 between intermediary metabolites. It is particularly important in the synthesis of fatty acids. Deficiency results in lethargy, loss of appetite, nausea and muscular pain. It may also be associated with liver cirrhosis. Good sources of Biotin are liver, kidneys, egg-yolk, vegetables nuts and cereals.

82. Recommended daily intakes are given in Table 2.5.

2.6.9 Vitamin C (Ascorbic Acid)

83. Although the best known of the vitamins, the full functions of Vitamin C remain to be elucidated. Ascorbic acid and dehydroascorbic acid form an oxidation/reduction system. Of particular importance are the reactions which require molecular oxygen. It is known to be involved in the synthesis of collagen, the metabolism of amino acids, the production of hormones in the adrenal glands and the conversion of folic acid to its active metabolite. It has an important role in stimulating iron absorption. Historically, scurvy has been the most devastating of the deficiency diseases in the maritime services. After 40 days on a diet free of ascorbic acid, the hair follicles enlarge and keratinize, which during the succeeding 40 days develop hemorrhages and the characteristic signs of scurvy. After 120 days hemorrhaging under the skin, in the gums, muscles and internal organs occurs with changes in bone structure and deformation of the teeth. The half life of Vitamin C appears to be in the order of 16 days (28).

84. Evidence is available from both experimental and field studies that scurvy can be both cured and prevented by a diet containing between 10 mg (6) and 20 mg (25) of Ascorbic Acid. In both cases, allowing for a margin of safety, the recommended intakes are 30 mg per day. In North America the recommended allowances are somewhat higher at 60 mg per day (2, 27).

85. Good sources Ascorbic Acid are citrus and other fruits, green vegetables and liver. Potatoes are an important source of Vitamin C but the concentration decreases by up to 80% on winter storage. Cooking destroys much of this vitamin and this should be taken into account when calculations of intake are made.

86. Recommended daily intakes are given in Table 2.5.

Fat Soluble Vitamins

2.6.10 Vitamin A (Retinol)

87. Vitamin A is of great importance for maintenance of health, normal growth, vision and reproduction. It is this vitamin which forms the visual pigment in the eye and appears to be necessary for the stability of cellular and subcellular membranes. Vitamin A can be obtained directly in the food or can be manufactured in the body from carotene pigments from ingested plant material. It is stored in the liver and in health, these reserves are sufficient to meet the body's requirements for one year or more. However, these reserves are rapidly depleted in infections hyperthermia and poisoning. The typical deficiency syndrome is night blindness.

88. Dietary intakes should be calculated on the basis of body weight, and allowances made for the contribution of carotenes to the total intake, as absorption rate differ widely between different foods and different people. Good sources of Vitamin A are fish oils, liver, milk fat and egg yolk. Green vegetables and carrots are rich in carotenes.

89. The units used are Retinol Equivalents to cover both Vitamin A and carotenes. Recommended intakes of Retinol Equivalents (RE) in both the US (2) and Canada (27) are for 1000 mcgRE per day. Excessive intakes of Vitamin A are known to be toxic and intakes above 7500 mcgRE should be avoided.

90. Recommended daily intakes are given in Table 2.5.

2.6.11 Vitamin D

91. Vitamin D can be ingested in food in addition to being formed in the skin under the influence of sunlight. It occurs in a number of forms. Its activity is closely related to the functioning of parathyroid hormone and calcitonin and is necessary for normal calcium metabolism and the maintenance of body calcium balance. In adults exposed to normal levels of sunlight, the body's requirement is generally met by skin synthesis. In children where bone growth is active the requirements are greater, and the recommended level of dietary intake after the age of 7 years is 2.5 mcg/day (6). The US recommendation (2) shows a decreasing requirement with growth. The UK (25) do not consider that a dietary intake is necessary if exposure to the sun is adequate. Where this is not the case, either because of occupational or seasonal considerations, the recommended levels of intake are 10 mcg/day.

92. All the D vitamins are toxic in large quantities. Good sources of Vitamin D are fish oils.

93. Recommended daily intakes for servicemen at all activity levels are 5-10 mcg per day.

2.6.12 Vitamin E (Tocopherol)

94. Vitamin E acts as an anti-oxidant in the body, preventing the oxidation of unsaturated fatty acids, Vitamin A and enzyme thiol groups. Intake is in the form of aTocopherol and related compounds. Intake is expressed as tocopherol equivalents (TE).

95. Good sources of Vitamin E are vegetable oils, particularly wheat germ oil, cereals and eggs. The signs of deficiency are not very marked.

96. Recommended daily intakes are given in Table 2.5.

2.6.13 Vitamin K

97. Vitamin K is involved in the process of blood clotting; it may have a number of other actions. The human requirement is not well known but as it is readily available in green plant cells, deficiency states are unlikely on a normal diet. Severe diarrhoea and other intestinal complains will impair absorption of the vitamin.

98. Good sources of Vitamin K are green vegetables such as cabbage and spinach.

99. Recommended daily intakes are given in Table 2.5.

Table 2.5 Recommended Daily Intakes of Vitamins for the Military*

Vitamin	Unit	Male	Female
Thiamin (B1)	mg	1.6 **	1.2
Riboflavin (B2)	mg	1.9 **	1.4
Niacin (B3)	mgNE	21 **	16
Vitamin B6	mg	2.2	2.0
Vitamin B12	mcg	3.0	3.0
Folic Acid	mcg	400	400
Biotin	mcg	100-200	100-200
Pantothenic Acid	mg	4-7	4-7
Vitamin C	mg	60	60
Vitamin A	mcgRE	1000	800
Vitamin D	mcg	5-10	5-10
Vitamin E	mgTE	10	8
Vitamin K	mcg	70-140	70-140

* Adapted from Reference (3).
** Assumes an intake of 3200 kcal per day for men, 2400 kcal for women.

2.7 WATER

2.7.1 Water Balance

100. Although humans can survive for 40-50 days without the other nutrients described in this chapter, death usually occurs after about 10-15 days without water consumption. The physiological importance of water is demonstrated from the fact that it comprises between 40 and 70% of a human's total body weight (See review by Senay & Pivarnik (29). This large range is due to the commensurately large variation among people in

their body content of fat, a tissue which contains little water. Thus for two people of similar weights but different fat contents, the fatter individual will have less total body water.

101. In a comfortable ambient temperature normal water loss from an average sized sedentary male is about 2.6 litres per day, lost in varying proportions from the gastrointestinal tract, the respiratory tract, through the skin and from the kidneys. This loss is balanced by intake of fluids (1.3 litres), water in solid food (1 litre) and water liberated during cellular oxidation of food (0.3 litres). This state of water balance, euhydration, is normally maintained by humans with unlimited access to fluids under comfortable climatic conditions. The monitoring of body weight is a simple method of checking whether water loss has exceeded water intake. A state of hypohydration is usually defined as a fluid loss amounting to greater than 2% of the normal body weight.

102. The amount of fluid intake required to maintain euhydration is a direct function of body size, the proportion of body mass consisting of fat, metabolic rate and climatic conditions. The human physiological system will always attempt to maintain body temperature at the expense of maintaining fluid balance (30). Thus, increased physiological exertion, high ambient temperatures, or a combination of both can lead to water losses (as sweat) as high as 2 litres per hour (31). In the absence of increased water intake, the body cannot compensate for such extreme losses which, if sustained, can and have led to fatalities.

2.7.2 Survival Water Requirements

103. Minimum water requirements for survival were the subject of much study during World War Two when there was a demand for recommendations for shipwrecked personnel or soldiers in the desert. A summary of British studies was written by Ladell (32) who concluded that during fasting, water intake of 0.8-0.9 litres per day was necessary to prevent weight loss even in a temperate climate. He found that a loss of 5% body weight after 24 hours water deprivation was tolerable, but a 10% loss produced gross physical and mental deterioration. Gamble (33) reported that during a period of fasting for six days the minimal urine water requirement per day would be about 0.6 litres, assuming 1.4 osmolar as the physiological maximum concentrating power of the kidney. Estimating insensible water loss at about 1 litre would make a total obligatory expenditure during fasting of some 1.6 litres of water per day. With this assumption, he calculated that the minimal requirement for water intake during fasting under normal environmental conditions and near basal energy expenditure would be about 0.8 litres. The remaining 0.8 litres would become available from the fasting catabolism of body tissues.

104. Hervey and McCance (34) in a follow up to this work found that when 100 g of carbohydrate (400 kcal) and 250 ml water were provided as a survival ration per day for three days, by the third day water balance, although negative, was about 200 ml better than on a ration containing only 250 ml water. It is their opinion (35) that on a ration of 100 g

carbohydrate and 500 ml water men would lose 1 to 2% of their body weight per day, would remain fairly well for one week and survive for two or more. In a more recent experiment conducted by Harrison, Smith & Golden (36) at a temperature of 20°C, high humidity and with subjects performing the minimal of activity 100 g carbohydrate (barley sugar) and 1 pint (568 ml) water were provided per day for seven days, with no water being taken on the first day. They found body weight losses of only 5-6% after seven days. These results suggest a beneficial effect of carbohydrate. Conversely, water requirements increase with diets high in salt or in protein and diets with an excessive fat content. This is due to the need to excrete waste products in the urine.

2.7.3 Field Applications

105. Brown et al. (37) calculated the expected durations for men in life rafts with restricted water supplies at various environmental temperatures and these are depicted in modified form in Table 2.6.

106. Fluid intake during military field trials over a wide range of ambient temperatures have been summarized by Welch et al. (38) and Buskirk & Boyer (39) have related water requirements for a standard man to the level of activity and thermal environment. These range from 1.2 litres per day for motorized arctic travel to 17.6 litres per day when 8 hours hard work each day was performed in a hot climate (Air temperature 49°C). Recent American trials determined that their soldiers consume 2.7-4.3 litres per day of fluids, including moisture in food, water added to rations and drinking water (40,41,42). Practically, euhydration is almost ensured if fluid intake can account for sweat loss. Therefore the reader may find it worthwhile to refer to Shapiro et al. (43), and the references contained therein, for equations to predict sweat loss for specific work loads, climates and clothing assemblies.

2.7.4 Dehydration

107. As discussed above, a water loss of greater than 2% of body weight indicates that the body is in a state of hypohydration, which, if allowed to reach 5-10% weight loss, can be associated with potential health hazards and marked physical performance impairments (discussed in another chapter of this report). Fluid deficits of 15-25% body weight are probably fatal, the former in hotter and the latter in cooler temperatures. The compensatory physiological adaptations which accompany long term exposure to heat stress or to altitude do not include protection from the debilitating and hazardous effects of dehydration. In other words, one cannot physiologically acclimatize to hypohydration in a manner analogous to heat acclimatization. Although the once popular practice of restricting water intake in military personnel may familiarize them with the subjective feelings associated with dehydration, the high probability of real physiological damage associated with such "water discipline" makes it an unacceptable practice.

108. A direct quote from Stevenson (44) which summarizes some of the classical work of Adolf (45):

"Men in the desert, even when water is freely available, voluntarily dehydrate themselves between meals and make up their fluid deficits during meals. This voluntary dehydration may reach five per cent of the body weight, sufficient to limit the physical performance of the man. Voluntary dehydration is reduced if meals are regular, if ample potable water is available, and if there is sufficient leisure to drink it. Voluntary dehydration is increased by rapid sweating. It is therefore necessary under these conditions that men should be encouraged to drink more water than they want, especially during periods of prolonged activity. At the termination of dehydration men drink copiously for the first 15 or 20 minutes, and, if the deficit is not greater than about two per cent of their initial body weight, they replace it within this time. If the loss is greater than two per cent, water ingestion proceeds more slowly after 15 or 20 minutes drinking, and a greater length of time is required for complete removal of the deficit. There may be adaptation to water lack, rendering voluntary dehydration more insidious as the day passes"

109. To counteract the potential for voluntary dehydration it is recommended that fluid losses be replaced by drinking 100 to 200 ml several times per hour during prolonged exposure to heat stress. Tables 2.6 and 2.7 give a indication of water requirements for different activities in different climates.

Table 2.6 Relationship Between Air Temperatures and Time Required to Reach Limiting Weight Deficits on Various Initial Water Supplies

Air Temp °F (°C)	Water Intake US Quarts (mls)	Days to Limiting Weight Deficit (%) 10%	20%
50 (10)	0 (0)	5.2	11.1
	1 (909)	5.9	11.8
	4 (3636)	8.1	13.9
70 (21.1)	0 (0)	4.2	9.1
	1 (909)	4.8	9.7
	4 (3636)	6.5	11.7
90 (32.2)	0 (0)	2.1	4.7
	1 (909)	2.5	5.2
	4 (3636)	3.7	6.3

Modified from Brown (37).

Table 2.7 Water Requirements for Different Activity Levels at Different Air Temperatures (Assumes relative humidity <45%)

Activity	Daily Mean Air Temperature °C					
	16	21	27	32	38	43
Hard Work -8hrs during the day	3.5	5.0	10.5	15.0		
Hard Work -8hrs during the night	2.0	2.5	4.0	7.0	10.5	14.5
Resting in Shade	1.75	2.0	3.0	5.5	8.75	12.5

Modified from Adolph (45) Page 121, Figure 8-5.

2.8 MINERALS AND TRACE ELEMENTS

110. This section considers those minerals and trace elements known to be of importance in the human body. Table 2.8 gives recommended daily intakes from the Committee on Dietary Allowances of the US National Academy of Sciences (2). A listing of the available information from each NATO Nation is given in Table 2.9.

2.8.1 Sodium and Potassium Chloride

111. Sodium, closely associated with chloride, is the principal mineral involved in maintaining blood and other extracellular volumes. When intakes are discussed the difference between sodium and salt (sodium chloride) intake should be made clear. 1 g of sodium is equivalent to 2.54 g of sodium chloride.

112. In temperate climates, a healthy adult can maintain sodium balance with an intake of well under 1 g of salt per day (46). The average intake in the US and UK and probably in most other NATO nations is somewhere in the region of 10 to 20 times this value. The estimated salt intake in the civilian US community is 16.5 g per day. The salt intake of military populations may well be in excess of this value.

113. A high salt intake appears to be a major factor in the development of hypertension and its potential consequences, heart disease and stroke. Thus in contrast to a minimum daily requirement, a maximum daily intake is a more relevant concept.

114. Despite recommendations that diets should contain no more than about 1.1 to 3.3 g of sodium per day, diets with less than 3 g of sodium (7.6 g salt) are likely to be considered unacceptable by today's serviceman. It is clear however, that the high levels currently consumed need to be reduced.

115. The quantities of potassium and sodium in the body are similar, but unlike sodium (mainly extracellular), 95% of the body potassium is intracellular, mainly in the muscle cells. Cell levels are critical for nerve and muscle function. Blood levels have little relevance to the amount in the tissues. Both high and low concentration effect heart function and can cause death. Potassium is readily available in the diet and deficiency states are very rare in healthy people.

116. Salt requirements increase during profuse sweating. Although sweat is hypotonic, the associated losses of potassium and sodium chloride can be severe with sweat rates of 8-10 litres per day. During hard physical work in very hot climates, up to 20 g of salt (as sodium chloride) may be lost in sweat. This will reduce with acclimatization as sweat becomes more dilute, (47) and it is unlikely that losses much above 10 g of salt per day will be maintained. Thus, with the current high dietary intakes, salt supplementation will only be necessary in extreme cases and should be in the form of additional salt added to the food. Salt tablets and salt water drinks are not recommended. Even as long ago as 1944, (48) the statement was made that "...salt supplements are not needed and may actually be deleterious; that the average diet...affords adequate protection against salt depletion." More recent information suggests that potassium losses in sweat do not decrease with acclimatization to heat in contrast to sodium losses, and that attention should be given to potassium nutritional content if personnel are expected to exercise at high sweat rates for several days (49).

117. With regard to the maintenance of physical performance during activities causing high sweat rates and electrolyte losses, Pitts et al. (50) stated that "...the best performance of intermittent work (is) achieved by replacing water loss hour by hour and salt losses meal by meal;" there is no strong evidence to warrant changing this feeding strategy, by for example, adding electrolytes to drinking water. The one exception may be when wearing protective clothing with a respirator where solid food intakes may be impossible, although a recent American evaluation of electrolyte supplemented fluid intake in such conditions showed no benefit compared to plain water for periods of up to 12 hours (51).

2.8.2 Calcium and Phosphorus

118. Calcium is an important mineral required for growth of tissue and bone. It is particularly important during growth. Low calcium intakes are implicated in the development of osteoporosis.

119. The major source of calcium in the diet is milk and milk products.

120. No injurious effects occur when the calcium intake is between 300 and 2000 mg. Calcium requirements have been estimated by FAO/WHO (6) at between 400 and 500 mg per day. The upper of these two limits has been adopted by the UK (25). Higher values are recommended in the USA (2), due in part to the high protein intakes which may affect calcium metabolism and, accordingly an intake of 800 mg/day is recommended. In the military the range is 800-1200 mg/day.

121. Dietary phosphorus is always in the form of phosphates.

122. Phosphorus requirements in many ways parallel calcium requirements. Additionally, however, many active chemicals such as the B vitamins are only effective when combined with phosphate. Phosphate is also an integral part of the high energy phosphates such as ATP, and was used in Germany in World War 1 in an attempt to alleviate fatigue. More recent evidence suggests there may be some scientific basis for this (52).

123. Although the ratio of calcium to phosphorus in bone is 2:1 it is much lower in soft tissues. Calcium to phosphorus ratios in the diet should therefore by between 1:1 and 1.5:1. Adequate supplies of Vitamin D are required for efficient calcium and phosphorus mobilization.

2.8.3 Iron

124. Iron is needed for the production of haemoglobin, and other iron containing proteins concerned with the transport of oxygen. Some iron can be stored in the liver, spleen and bone marrow, but low intakes may deplete these stores.

125. Although excessive exercise may cause loss of iron from the destruction of red blood cells, for active normal males iron supplements are not necessary. In females, iron may be depleted due to menstrual losses and in pregnancy. For male juveniles and women of all ages, it is prudent to be conscious of the iron content of the diet.

126. Dietary iron occurs in two major forms, haem iron (from animal protein) and non-haem iron (iron salts) found in both animal and plant food. Whereas some 23% of dietary haem iron is absorbed from the diet, the figure for non-haem iron is 3 to 8%. This latter figure can be more than doubled in the presence of animal protein or vitamin C but reduced in the presence of certain cereal and legume proteins. Vitamin C is proving to be one of the chief promoters of iron absorption.

127. The allowances proposed by FAO/WHO (6) are 5-9 mg/day for men and 14-28 mg/day for women. The UK (25) recommendation is 10 mg/day for men and 12 mg/day for women, although in the latter case, where menstrual losses are higher, they propose that intake should be increased by medicinal supplements of iron. The US recommendations (2) are 10 mg/day for males and 18 mg/day for females.

2.8.4 Other Minerals and Trace Elements

2.8.4.1 Magnesium

128. Magnesium is needed for enzymatic activity, muscular contraction and protein synthesis. Deficiency could cause muscular weakness. A normal diet should be adequate for magnesium balance. The recommended daily intake is 350-400 mg/day, although, certain authorities suggest that in heavy exercise, intakes should be increased to 500 mg/day to balance sweat losses.

2.8.4.2 Zinc

129. Zinc is associated with the action of a large number of enzymes involved in energy production and protein synthesis. The quantity of zinc in the body is quite high, about half the size of the iron store. The dietary intake necessary to maintain zinc balance is 10-15 mg/day.

2.8.4.3 Iodine

130. Iodine is a component of the thyroid hormones. As the iodine content of the food varies with that of the soil on which it was grown, it has been common practice in a number of countries to add small quantities to table and cooking salt to ensure an adequate intake.

2.8.4.4 Fluorine

131. Fluorine (as fluoride) is an essential nutrient which is found in the enamel of teeth and in bone. Fluorine is found in varying amounts in most foods and water supplies. A concentration of 1 part per million (1 mg/l) has been shown to be safe and efficient in the prevention of dental caries.

2.8.4.5 Other Trace Elements

132. These include copper, selenium, molybdenum, manganese and chromium. Recommended intakes for these and for the elements listed above are given in Table 2.8.

133. Since toxic levels for many trace elements may only be several times usual intakes, the upper levels of trace elements given should not be habitually exceeded.

Table 2.8 Recommended Daily Intakes for Minerals*

Mineral	Unit	Intake
Sodium	g	1.1-3.3 **
Potassium	g	1.9-5.6
Calcium	mg	800-1200
Phosphorus	mg	800-1200
Iron	mg	10-18
Magnesium	mg	350-400
Zinc	mg	15
Iodine	mcg	150
Fluorine	mg	1.5-4.0
Copper	mg	2-3
Selenium	mcg	50-200
Molybdenum	mcg	150-500
Manganese	mg	2.5-5.0
Chromium	mcg	50-200

* Adapted from Reference (3)
** See para 2.8.1

Table 2.9 Recommended Dietary Intakes for Military Personnel of those NATO Nations Participating in RSG 8 Activities

	Unit	NATION							
		Can	Den	FRG	NL	Nor	UK	US	FAO /WHO
Protein	g	57	90	100	80	72	72	100	49**
Vitamin B1*	mg	1.3	1.5	1.6	1.3	1.5	1.2	1.6	1.2
Vitamin B2*	mg	1.6	1.7	1.9	1.9	1.7	1.6	1.9	1.8
Vitamin B3*	mgNE	23	19	18	..	19	18	21	20
Vitamin B6	mg	0.015#	2.2	2.0	..	..	..	2.2	..
Folic Acid	mcg	210	..	400	..	..	300	400	..
Vitamin B12	mcg	2	..	5	..	..	..	3	..
Vitamin C	mg	60	60	75	50	60	30	60	30
Vitamin A	mcgRE	1000	1000	1000	850	1000	750	1000	750
Vitamin D	mcg	2.5	5	5	..	5	10	5	2.5
Vitamin E	mgTE	10	..	12	..	..	..	10	..
Calcium	mg	800	600	800	800	600	500	800	500
Phosphorus	mg	800	..	800	..	..	..	800	..
Iron	mg	8	10	12	10	10	10	10	5
Magnesium	mg	240	..	350	..	..	..	350	..
Zinc	mg	9	..	15	..	..	..	15	..
Iodine	mcg	160	..	200	..	..	..	150	..

* Assumes an energy intake of 3200 kcal.
** Assumes 70 kg man.
\# per g protein.
.. Recommendation not made.

Notes: FAO/WHO (Reference 6) values given for comparison.
Belgium does not have specific recommendations for Military personnel.

Where a range is used, the lower figure is presented.

2.9 SUMMARY AND CONCLUSIONS

134. Establishing recommended dietary intakes or dietary allowances for selected nutrient on an individual basis is by nature an imprecise calculation with the result that recommendations are set, not for individuals but for particular subgroups of the population. These calculations are based on the best evidence currently available which is often far from complete or totally conclusive.

135. Using data available from civilian sources and from a range of NATO nations, recommendations on which dietary management can be made have been presented.

2.10 RECOMMENDATIONS

136. The recommendations made in this chapter are based on information currently available. Modifications will need to be made as additional research data becomes available. This may result from civilian research or research conducted under the auspices of NATO. Nutritional strategies to enhance military performance are a relatively new concept and covered in more detail elsewhere in this report. Dedicated research in this area will be required if nutritional status is to contribute towards the health and performance of NATO military personnel.

2.11 REFERENCES

1. Truswell, A.S. (1976). Symposium on "Some Aspects of Diet and Health". Proc. Nutr. Soc. 35: 1-14.

2. Committee on Dietary Allowances. (1980). Recommended Dietary Allowances. 9th Edition, Washington, D.C.: National Academy of Sciences.

3. Army Regulation 40-25 (Naval Command Medical Instruction 10110.1, Air Force Regulation 160-95). Nutritional Allowances, Standards, and Education. Headquarters Department of the Army, the Navy, and the Air Force. 15 May 1985.

4. Durnin, J.G.V.A. et al. (1973). *How much food does man require?* Nature 242: 418.

5. Durnin, J.V.D.A. & Passmore, R. (1967): Energy Work & Leisure. Heineman Educational books. pp.104.

6. FAO/WHO. (1974). Handbook on Nutritional Requirements. Food and Agriculture Organisation of the United Nations. Rome. FAO/WHO.

7. Durnin, J.G.V.A. et al. (1985). A new method of assessing fatness and desirable weight for use in the armed services. Ministry of Defence Contract Report. London.

8. Donhoffer, S.Z. & Vonotozky, J. (1947). The effects of environmental temperature on food selection. Amer. J. Physiol. 150: 329-333.

9. Johnson, R.E. & Kark, R.M. (1947). Environmental and food intake in man. Science. 105: 378-379.

10. Iampietro, P.F. et al. (1957). Caloric intake during prolonged cold exposure. Quartermaster Research and Engineering Center. Technical Report EP-66, Natick Massachusetts.

11. Gray, E.L. et al. (1951). Nutritional requirements for men at work in cold temperate and hot environments. J. Appl. Physiol. 4: 270-275.

12. Consolazio, C.F. (1969): Energy Metabolism and Extreme Environments. Proceedings of the Eighth International Congress on Nutrition, Czechoslovakia, 28th August-5th September 1969.

13. Consolazio, C.F. (1963). Environmental temperature and energy expenditures. J. Appl. Physiol. 18: 65-68.

14. Consolazio, C.F. (1966). Energy metabolism at high altitude. J. Appl. Physiol. 21 1732-1740.

15. Hansen, J.E. et al. (1967) Oxygen uptake in man during exhaustive work at sea level and high altitude. J. Appl. Physiol. 23: 511-522

16. Malhotra, M.S. et al. (1978). Calorie and fluid requirements of troops at high altitude. Commonwealth Defence Science Organization. Food Study Group. Toronto, Canada. 5th-9th June 1979.

17. Soule, R.G. et al. (1978). Energy expenditure of heavy load carriage. Ergonomics. 21 No 5: 373-381.

18. Winsmann, F.R. & Goldman, R.F. (1976). Methods for evaluation of load-carriage systems. Perceptual and Motor Skills. 43: 1211-1218.

19. Pimental, N.A. & Pandolf, K.B. (1979). Energy expenditure while standing or walking slowly uphill or downhill with loads. Ergonomics 21 No 8: 963-973.

20. Givoni, B. & Goldman, R.F. (1951). Predicting metabolic energy costs. J. Appl. Physiol. 30: 429-433.

21. NACNE (1983). A Discussion Paper on Proposals for Nutritional Guidelines for Health Education in Britain. National Advisory Committee on Nutrition Education. The Health Education Council.

22. MAFF (1983). Ministry of Agriculture Fisheries and Food. Household Food Consumption and Expenditure 1982. London HMSO.

23. Darling, R.C., Johnson, R.E., Pitts, G.C., Consolazio, C.F. & Robinson, P.F. (1944). Effects of variations in dietary protein on the physical well-being of men doing manual work. J. Nutr. 28: 273-281.

24. FAO/WHO/UNO. (1985). Energy & Protein Requirements. Report of a joint FAO/WHO/UNO Expert Consultation WHO Tech. Rep. 724 pp:82.

25. DHSS (1979). Recommended daily amounts of food energy and nutrients for groups of people in the United Kingdom. Report by the Committee on Medical Aspects of Food Policy. London: HMSO.

26. Royal College of Physicians, London (1980). Medical aspects of dietary fibre. Tunbridge Wells. Pitman Medical.

27. Health & Welfare Canada. (1983). Recommended intakes of nutrients for Canadians. Ottawa, Government Publishing Center.

28. Hellman & Burns (1958) J. Biol. Chem. 230: 923.

29. Senay, L.C. & Pivarnik, J.M. (1985). Fluid shifts during exercise. In: Terjung, R.L. (ed.) Exercise and Sports Sciences Reviews, Volume 13. Collier Macmillan Canada: Toronto, pp 335-388.

30. Astrand, P.-O., & Rodahl, K. (1970). Textbook Of Work Physiology. McGraw- Hill: New York.

31. Saltin, B. (1964). Aerobic and anaerobic work capacity after dehydration. J. Appl. Physiol. 19: 1114-1118.

32. Ladell, W.S.S. (1947-48). Effects on man of restricted water-supply. Brit. Med. Bull. 5: 9-12.

33. Gamble, J.L. (1944). Water requirements of castaways. Proc. Am. Phil. Soc. 88: 151-158.

34. Hervey, G.R., & McCance, R.A. (1952). The effects of carbohydrate and sea water on the metabolism of men without food or sufficient water. Proc. Roy. Soc. B. 139: 527-545.

35. Hervey, G.R. & McCance, R.A. (1954). Emergency rations. Proc. Nutr. Soc. 13: 41-45.

36. Harrison, J.R. (1982). Nutritional aspects of submarine escape survival. Commonwealth Defence Scientific Organization Conference on Nutrition. Canberra, Australia, October 1982.

37. Brown, A.H., Gosselin, R E., & Adolph, E.F.. (1947). In: Adolph, E.F. (ed.) Physiology Of Man In The Desert. Interscience Publishers, Inc: New York, pp.280-314.

38. Welch, B.E., Buskirk, E.R. & Iampietro, P.F. (1957). The relation of climate and temperature to food and water intake in man. U.S. Army Medical Nutrition Laboratory Report No. 213. Denver, Colorado.

39. Buskirk, E.R. & Boyer, L.L. (1965). Water and calorie requirements as predicted from environmental conditions and physical activity. In: Vaughan, L. (ed.) Nutritional Requirements For Survival In The Cold And At Altitude. Arctic Aeromedical Laboratory: Fort Wainwright, Alaska, 1965, pp.49-83.

40. Hirsch, E., Meiselman, H.L., Popper, R.D., Smits, G., Jesior, B., Lichton, I., Wenkam, N., Burt, J., Fox, M., McNutt, S., Theile, M.M. & Dirige, O. (1983). The effects of prolonged feeding meal, ready-to-eat (MRE) operational rations. USANRDC Technical Report No. TR-85/035.

41. Popper, R., Hirsch, E., Lesher, L., Engell, D., Jezior, B., Bell, B., & Matthew, W.. (1987). Field evaluation of the Improved MRE, MRE VII, and MRE IV. NRDEC/USARIEM Technical Report No. TR-87/027.

42. Askew, E.W., Claybaugh, J.R., Cucinell, S.A. Young, A.J. & Szeto, E.G. (1986). Nutrient intakes and work performance of soldiers during 7 days of exercise at 7,200 feet altitude consuming the meal, ready-to-eat (MRE) operational rations. USARIEM Technical Report No. T3-87.

43. Shapiro, Y., Pandolf, K.B. & Goldman R.F. (1982). Predicting sweat loss response to exercise, environment and clothing. Eur. J. Physiol. 48: 83- 96.

44. Stevenson, J.A.F. (1958). Survey Of Survival Feeding. Defence Research Board Report No. DR 125. Canadian Department of National Defence: Ottawa.

45. Adolph, E.F. (1947). (ed.) Physiology Of Man In The Desert. Interscience Publishers, Inc: New York.

46. Dahl, L.K. (1972). Salt and Hypertension. Am. J. Clin. Nutr. 25: 234-244.

47. Sawka, M.N., Francesconi, R.P., Young, A.J. & Pandolf, K.B. (1984) Influence of hydration level and body fluids on exercise performance in the heat. J. Amer. Med. Assoc. 252: 1165-1169.

48. Conn, J.W. & Johnson, M.W. (1944). Improvement of ability of soldier to work in humid heat. Salt requirements of acclimatized men performing hard work in tropical climates. OEMcmr-232 Report No. 10 to the Com. Med. Res., O.S.R.D. July 1944.

49. Armstrong, L.E., Hubbard, R.W., Szlyk, P.C., Matthew, W.T. & Sils, I.V. (1985). Voluntary dehydration and electrolyte losses during prolonged exercise in the heat. Aviat. Space Environ. Med. 56: 760-770.

50. Pitts, G.C., Johnson, R.E. & Consolazio, F.C. (1944). Work in the heat as affected by intake of water, salt and glucose. Am. J. Physiol. 142: 25 -259.

51. Ross, M.S., Francesconi, R.P., Levine, L., Shukitt, A.V., Cardello, A.V., Warren, P.H., Munro, I., Banderet, L., Poole, P.M., Frykman, P. & Sawka, M. (1987). Effects of a NBC nutrient solution on physiological and psychological status during exercise in the heat. US Army Research Institute of Environmental Medicine Report No. T25-87, Natick, Massachusetts, July 1987.

52. Cade, R., Conte, M., Zauner, C., Mars, D., Peterson, J., Lunne, D., Hommen, N. & Packer, D. (1984). Effects of phosphate loading on 2,3-diphosphoglycerate and maximal oxygen uptake. Med. Sci. Sports Exercise 16: 263-268.

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CHAPTER 3

NUTRITION AND OPTIMAL PHYSICAL PERFORMANCE

3.1 INTRODUCTION

137. The physical performance demands of military personnel range widely depending on the trade of the individual soldier, the mission of a unit, the environment in which the mission is to be accomplished, and whether the scenario is performed during peacetime; training, or actual conflict. These physical demands can be rather sedentary in nature, similar to those encountered in the civilian sector, in which case national nutritional guidelines for the quantity and quality of energy consumption should suffice for feeding military personnel. Military activities can, however, result in energy demands which are far greater than those experienced in civilian life. Mean daily energy expenditure during military field trials has been reported to range as high as 10,000 kcal in some cases (1,2). Moreover, activities which usually demand minimal energy expenditure can become quite demanding when they are performed in special environments to which the soldier may be exposed, for example, heat, cold and protective clothing. The ability to adequately fuel these energy demands, to avoid fuel exhaustion and the associated performance impairments, and thus to enhance performance via appropriate energy consumption (i.e. food intake) could be critical in the life or death situations in which military personnel are trained to operate.

138. Since World War II, several reviews of the special nutritional needs of the military have been published and a detailed annotated bibliography was prepared by Buskirk (3) for the American Committee on Military Nutrition Research, Food and Nutrition Board, of the National Research Council Commission on Life Sciences. More recently, this same committee published the proceedings of a unique workshop (4) which provides both a detailed historical perspective and an up-to-date review of the effects of deviations from recommended daily nutritional allowances on physical performance and physiological homeostasis in controlled laboratory experiments as well as in military field trials.

3.2 SELECTIVE MACRONUTRIENT UTILIZATION AND EXERCISE INTENSITY

139. Newsholme and Leech (5) calculated the duration of time during which an average sized man (65 kg body weight, 12% body fat) could either run at a marathon pace (approx 84 $kJ.min^{-1}$) or walk (approx 6.4 $km.h^{-1}$, 21.7k $J.min^{-1}$) using only one of the body's fuelstores (Table 3.1).

Table 3.1 Fuel Reserves in Average Man

Fuel store	Reserve g	Reserve kJ	Fuel sufficient for Walking days	Fuel sufficient for Running min
Adipose tissue	9000	337000	10.8	4018
Liver glycogen	90	1500	0.05	18
Muscle glycogen	350	6000	0.20	71
Circulating glucose	20	320	0.01	4
Body protein	8800	150000	4.8	1800

from Newsholme & Leech, 1983

140. In contrast with these theoretical calculations, the transduction of the chemical energy in these fuel supplies into mechanical work by muscle tissue depends on simultaneous contributions by all of the fuel reserves. The energy demands of sedentary activities are covered approximately equally by the catabolism of fat and carbohydrate; the contribution of carbohydrates increases as the intensity of exercise increases until almost the entire energy demand of supramaximal exercise of a 30-60 second duration is met by carbohydrate metabolism. Although protein metabolism probably contributes significantly more to energy metabolism than previously believed (6), Table 3.1 demonstrates that it is unlikely that the body's stores of protein and/or fat would be depleted to the extent that the capacity to transduce energy to the working muscles would be impaired.

141. The final report of NATO AC/243 (Panel 8) Research Study Group 4 on Physical Fitness identified aerobic capacity, muscular strength and muscular endurance as important components of military occupational requirements (7). Prolonged forced marches, lifting and loading (for example, artillery shells or sandbags), and hand-to-hand combat exemplify activities which correspond to each of the fitness components mentioned above. Such activities span a wide range of relative intensities of physical exertion from the submaximal activities which may be performed for hours, to activities which demand short bursts of explosive power for only a few seconds. With regard to specific macronutrients, the availability of carbohydrates has been shown to have direct implications for the kind of physical performance referred to above.

3.3 MUSCLE GLYCOGEN AND EXERCISE PERFORMANCE

142. Recent review papers describe the history of laboratory studies, beginning in Scandinavia in the 1930's, which demonstrated that a carbohydrate-rich diet increases the length of time exercise intensities of 70-85% of maximal aerobic power (VO_2 max) can be maintained, and that this is a direct function of the concentration of glycogen in the

exercising muscles before exercise. Later studies demonstrated that both muscle and liver glycogen concentrations were directly influenced by the amount of consumed dietary carbohydrate, and that both glycogen levels and endurance exercise performance covaried with changes in the absolute amount of ingested carbohydrates (8,9).

143. More recent studies have demonstrated that the depletion of glycogen from skeletal muscle is associated with impairments in muscular strength and in the ability to perform short term, high intensity exercise lasting less than one minute (10,11,12,13).

144. Physical performance in a military scenario contrasts with the laboratory studies described above in that the former usually demands several days of physical activity as opposed to a single bout of exercise. Costill et al. (14) investigated the potential implications of dietary carbohydrate ingestion on three consecutive days of hard exercise. The exercise was commenced each day with a progressively lower muscle glycogen level when a relatively carbohydrate-poor diet (i.e. 40% of total calories) was consumed. It is reasonable to assume that exercise performance would be affected in a similar manner. When the same subjects consumed a eucaloric high carbohydrate diet (70%), muscle glycogen levels were almost completely restored to normal during the 24 h between exercise bouts.

3.3.1 Muscle Glycogen Changes During Military Activities

145. Do skeletal muscle glycogen levels become depleted in military personnel to the extent that exercise performance may become compromised? Very few studies have been carried out during actual military field trials because of the invasive nature of the biopsy procedure used to obtain a skeletal muscle tissue sample. In Swedish (15) and Canadian commandos (I. Jacobs, personal communication, November 1987), glycogen levels in the thigh musculature after 4-5 days of field trials were reported to be less than 50% of the pre-trial values. It is interesting to note that these decreases in glycogen occurred even when daily nutritional energy intake amounted to as much as 3700 kcal, of which carbohydrates comprised 64% or 580 g (15). This attests to the high energy demand, i.e. the intensity, of the activities performed in the field. Based on the direct relationship between changes in glycogen levels and the extent of the impairment of endurance performance, it was suggested that the glycogen levels observed in military personnel at the end of the field trials could be expected to be associated with a 30-40% decrement in endurance if the soldiers had been subsequently required to perform relatively high intensity tasks over a prolonged period of time. A concomitant 10-25% decrement in muscular strength or explosive power can also be expected with these decreases in muscle glycogen concentrations (10,11,12,13).

146. Self-pacing, or the work intensity at which soldiers choose to work may also be affected by the availability of glycogen in the exercising muscles. This was suggested in a study carried out at altitude (16), in which a group of soldiers whose daily energy consumption included 404 g carbohydrate per day, covered significantly greater distances during their

daily runs than did a control group consuming only 187 g carbohydrate per day. Further support comes from a study by Saltin (17) in two teams of soccer players, one of which exercised hard to become glycogen depleted the day before an experimental game. Film analyses of the players' movements during the game showed that the glycogen depleted team covered 20% less distance during the game, and that they sprinted only 15% of the time they were in motion, compared to 24% for the control team.

3.3.2 Glycogen Strategies

147. The most reasonable approach to avoid the performance impairments associated with glycogen depletion is to attempt to a) delay the onset of a glycogen exhausted state by commencing exercise with relatively high intramuscular stores; b) restore glycogen stores as rapidly as possible after exercise is completed so that the soldier is physiologically prepared for a subsequent exercise bout; c) provide an alternative source to fuel muscle contraction. Costill et al. (18) demonstrated that after exhaustive exercise in 72 kg male runners, glycogen levels could be almost completely restored to normal levels within 24 h when the subjects consumed 3700 kcal of which 70% (648 g) were carbohydrates. The rate of glycogen repletion was equally high when the carbohydrates were consumed over either two meals or seven meals during the day. This study also indicated that the rate of replenishment of glycogen was similar if the consumed carbohydrate was in a simple or complex sugar form.

148. Recent studies have suggested another strategy for delaying the onset of glycogen depletion by presenting the musculature with alternative fuels. The use of methyl-xanthines, such as caffeine, will increase the concentration of circulating free fatty acids. Skeletal muscle will consequently use more circulating fat as an energy source and thereby decrease the utilization of glycogen (19). Recent studies have also demonstrated that carbohydrates other than glycogen can be oxidized during exercise. For example, subjects in one study were able to maintain an exercise intensity of 71% VO_2 max for 33% longer when they drank a glucose solution during exercise (4.02 h) than when they exercised in the control condition (3.02 h). The authors interpreted their results as indicating that when fed carbohydrates during exercise, oxidation of carbohydrates other than muscle glycogen may result in the postponement of fatigue during strenuous exercise (20). Although there is recent strong evidence that the ingestion of either liquid or solid carbohydrates just before and/or during exercise can be beneficial (21), there are several studies showing no performance enhancement (22,23).

3.4 ADAPTATION TO FAT RICH DIETS

149. Although the relationship between exercise performance and carbohydrate consumption described above is well established, there are several potential logistical advantages to a high proportion of fat in field rations because of the high calorie density in fat relative to carbohydrates. The associated light weight, and compactness of such

rations, relative to eucaloric mixed or carbohydrate-rich rations were attractive to researchers during World War II. An attempt to evaluate such a ration was made by Kark et al (24), who provided a ration of pemmican (70% fat, 30% protein) and tea to a platoon during a physically demanding winter field trial. The results were disastrous, in that the platoon was rendered operationally useless within three days, suffering from ketoacidosis and dehydration. It is difficult to evaluate, however, if these results can be directly attributed to the lack of nutritional carbohydrate, or are rather an effect of caloric deficiency and/or dehydration.

150. Contrasting with the above, Phinney et al. (25) performed a well controlled laboratory study which examined the effects of 4 weeks of a carbohydrate-poor diet on subsequent exercise performance. Care was taken during this study to ensure that the recommended daily allowances for vitamins and minerals were consumed, and that the total caloric consumption was eucaloric relative to the control diet. The design of this study differs from those described earlier in this chapter in that the period of adaptation to the ketogenic diet was at least four times longer in this study. Their results suggest that endurance exercise performance may not be impaired after a prolonged period of adaptation to a fat and protein-rich diet. In their study, circulating glucose and muscle glycogen concentrations were normal after four weeks of this carbohydrate-poor diet, and the subjects were able to exercise for a similar duration during the experimental (151 min) and control (147 min) exercise bouts. The subjects in this study were very fit cyclists who may have a favorable training-induced disposition for high rates of gluconeogenesis. Whether or not the same findings would be applicable to less fit military personnel remains to be investigated. There are obvious implications however, for long-range patrols and/or covert observations units which may be required to be nutritionally self-sufficient for several weeks. A 50% reduction in the weight of rations to be carried and stored is significant not only for logistical reasons, but also because energy expended just to carry the rations would also be proportionately reduced.

3.5 MICRONUTRIENTS AND PERFORMANCE

151. Present knowledge about vitamin status and exercise performance has been recently reviewed by van der Beek (26,27). These reviews indicate that supplementation of either fat or water soluble vitamin intake, over and above that consumed according to normal national nutritional guidelines, will not enhance physical performance. In fact excessive consumption of both classes of vitamins may result in toxicity. In contrast, vitamin intake amounting to only 35% of RDA may result if attention is not paid to consuming a balanced diet (27). Such deficiencies lead to a marginal vitamin B1, B2, B6 and C status within 4-6 weeks, and van der Beek has observed concomitant impairments in indicators of endurance exercise performance (27).

152. Tyrosine is an amino acid precursor of catecholamine neurotransmitters contained in animal protein foods. The effects of acute

ingestion of 100 mg/kg of tyrosine were investigated in a recent double blind study with male military volunteers exposed to a combination of mild altitude and cold stresses (28). Tyrosine administration reduced the adverse effects of these stressors on performance tests of complex information processing, vigilance and reaction time and on mood states. Subjective feelings of cold stress, discomfort and headache were also reduced with the experimental treatment.

153. The use of another amino acid, l-tryptophan, has been tested in an attempt to increase the amount of sleep in personnel being transported across time zones and thereby minimize the negative effects of "jet lag". The results suggest that ingestion of l-tryptophan may promote sleep without the performance and responsivity impairments usually associated with sedating agents (29).

154. In neither of these latter two studies was physical exercise performance evaluated but the potential benefit indicated by the positive treatment effects warrants further research.

3.6 CALORIE RESTRICTION

155. Survival situations, emergencies, supply line breaks are all examples of military scenarios associated with caloric restriction. Some special military units may restrict their nutrition voluntarily to lower the loads to be carried on covert missions, long range patrols, etc. Early studies indicated that operational performance can apparently be maintained for at least two weeks with mean daily energy consumption of 1800-1900 kcal, even when mean daily energy expenditure was estimated at 3500 kcal (30). In this regard, it should be mentioned that VO_2 max has been reported in some studies to decrease by as much as 20% when energy intake is restricted to 400 kcal/day for up to ten days; other studies have reported no effect on VO_2 max (31). In such studies it is difficult to partition out the effects of calorie restriction from the confounding effects of other stressors such as dehydration, sleep deprivation, and other non-specific stressors.

156. Whether or not the measurement of VO_2 max is even a valid indicator of endurance performance of a soldier is debatable and this points to the main problem with past studies: the quantification of physical performance after caloric restriction. The extent of the negative caloric balance, and the associated performance impairments, will vary greatly, depending on the energy demand of the specific mission. In an excellent review of this topic, Grande (31) recently concluded that in the presence of sufficient nutritional consumption to ensure adequate vitamin status and to avoid ketosis, dehydration and hypoglycemia, performance (measured as VO_2 max and handgrip strength) was satisfactory during conditions of moderate energy expenditure up to a weight loss of 10% of the control body weight. Grande also emphasized that the experiments he reported were performed with fit young male subjects, and that tolerance to semistarvation may be different in less fit and older individuals.

157. A lightweight daily ration containing 2000 kcal was recently tested as the sole source of food for 30 consecutive days during a field trial with American Special Forces soldiers (32). Although weight loss in these soldiers (6% of original body weight) was significantly greater than in the control group consuming normal rations (2% of body weight), the effect on physical performance as equivocal. Although some indices of muscular strength and endurance, and VO_2 max were impaired to a greater extent in the energy restricted group, other performance tests suggested that the effects are similar to the impairments demonstrated by the control group consuming normal rations (32). Such performance impairments are therefore difficult to attribute to nutritional insufficiencies without further basic research.

3.7 ENVIRONMENTAL FACTORS

158. Environmental stress, by definition, adds to the demands placed on physiological organ systems to perform a specific task or amount of work. Regarding exercise performance the effect is typically to magnify the physiological responses to exercise. The net result is that fatigue occurs earlier or the rate of work output must be decreased in order to avoid fatigue. Therefore any nutritional manipulations or strategies which under normal conditions ameliorate the ability to meet this increased relative exercise intensity will probably be beneficial in the face of environmental stress.

159. Much environmental physiological research was carried out during and immediately after World War II, but since that time technological advances have been very successful in the development of means to protect personnel from adverse environments while maintaining or improving operational efficiency. Nutritional considerations described below may prove beneficial as an adjunct or back-up to technology.

3.7.1 Altitude

160. Almost 50 years ago it was estimated that a high carbohydrate diet would significantly increase the elevation than an unacclimatized man could tolerate while breathing ambient air (33). It was calculated than the increase would amount to 305-608 m above the normal 4573 m level. These calculations were based on the knowledge that more oxygen is needed to burn fat than to burn sugar to carbon dioxide and water. Mitchell and Edman (34) reviewed several studies showing a beneficial effect of high carbohydrate intake on "...mental efficiency, neuromuscular coordination, the capacity for muscular work, the field of peripheral vision, and the acuity of vision in dim light. It (carbohydrates) defers syncope for a longer time and decreases the severity of the symptoms of decompression sickness". These effects were most marked in comparison with diets high in protein content and less marked in comparison with normal uncontrolled diets. Mitchell and Edman (34) also indicate that these effects were observed with subjects breathing ambient air at altitude and that breathing oxygen may reduce the extent of the benefit.

161. Anorexia is associated with a sudden move to altitude, as is well demonstrated in recent reports with military personnel moved to 2194 m (35) and 4100 m (16). Even at the relatively mild altitude in the former investigation, energy consumption over a ten day period was only 67% of the calories required for energy balance in spite of the ad libitum access to 1200 kcal per meal. The resultant 3% body weight loss consisted predominantly of fat and was associated with a significant 5% decrease in VO_2 max. More marked impairments of endurance performance with increasing time at altitude could be expected because of the markedly reduced daily carbohydrate intake (260 g/day) which would decrease skeletal muscle glycogen stores. The latter study (16) suggested that the addition of 5-7 beverage packets per person per day, each consisting of 35-40 g of carbohydrate, would not only reduce the daily energy deficit but may also benefit the ability to perform endurance exercise while at altitude.

162. These results confirm the work of Consolazio et al. (36) which demonstrated enhanced exercise performance and reduced clinical symptamology in military personnel who consumed a carbohydrate-rich liquid diet compared to a control group during rapid ascent to altitude.

3.7.2 Cold Ambient Temperatures

163. Nude resting humans respond to the increased body heat loss in the cold by increasing heat production, i.e. metabolic rate, by five to sevenfold (37,38). The caloric cost of performing light exercise in cold air is also increased unless the cost of the exercise is greater than about five times the normal resting metabolic rate (38,39,40). This increased caloric cost is probably accompanied by a greater combustion of carbohydrates (i.e. glycogen) to perform a given amount of work in the cold (41). Harder exercise provides enough endogenous heat production to compensate for the increased heat loss in the cold (38,39,40,41).

164. Although protective clothing minimizes the likelihood that military personnel will be physiologically cold stressed for prolonged periods of time, it has been repeatedly observed that nutritional energy consumption is increased in military personnel in the cold. This is consistent with Brobeck's (42) speculation that food intake was a dependent variable involved in temperature regulation, demonstrated by the fact that:

"...animals eat to keep warm, and stop eating to prevent hyperthermia".

165. Empirical support for such an inverse linear relationship between voluntary caloric intake and local temperature was demonstrated (43) for North American soldiers living at temperatures between approximately -34°C and 33°C; the associated daily caloric intake ranged from 3100 to 4900 kcal, respectively.

166. Several studies subsequently reported that the increased caloric intake could not be directly attributed to increases in energy requirements because of cold, per se (44,45). These studies agree that any extra

energy requirements in a cold environment are probably because of the extra heavy clothing which imposes a resistance to body movement and decreases mechanical efficiency, and heavy foot-gear which results in an increase in energy expenditure.

167. A review of available military reports reveals that energy balance during heavy exertion in cold field environments could require a daily energy intake of as much as 4200-4500 kcal (46,47). This corresponds to about 45-63 kcal/kg per day for light to heavy work; additional calories would have to be provided to account for waste.

168. A detailed description of a mid-winter 78 day, 5440 km motorized patrol of the Arctic reported that nutritional and physical performance deficiencies were not observed during or after the patrol with the provision and consumption of the nutrients described in Table 3.2 (48).

Table 3.2 Mean Daily Values for Nutrients Provided and Consumed During Exercise "Musk Ox", February-May 1945 (48)

Nutrient	Provided	Consumed
Energy, kcal	5190	4400
Protein, g	145	120
Carbohydrate, g	575	520
Fat, g	225	190
Vitamin A, IU	6100	4900
Thiamine, mg	2.8	2.2
Riboflavin, mg	3.5	2.8
Niacin, mg	31	26
Vitamin C, mg	80	50

169. Fluid consumption during this patrol was about 1.2 l/day, ranging from 0.7 to 3.4 l, although most members of the patrol complained of being frequently thirsty and not having enough time to melt snow for sufficient water. A more recent study of subjects living at -23°C for five days in an environmental chamber demonstrated that consumption of 3 l of water per day was sufficient to maintain hydration, but even 1.5 l per day avoided impairments of endurance exercise performance in spite of a 3.5% body weight loss (49).

170. A recent human study has suggested that pharmacological manipulations may enhance cold tolerance by increasing the availability of fuels to the heat producing tissues of the body (i.e. skeletal muscle) (50). In this regard an animal study demonstrated that the pharmacological agent had a greater effect in the presence of ingested carbohydrates

compared to a lipid ingestion condition (51). Further research in this area is needed to confirm the potential to enhance the body's heat production, delay the onset of hypothermia during cold exposure, and the associated nutritional implications.

3.7.3 Hot Ambient Temperatures

171. In 1940 Lee (52) recognized that acute exposure to a hot environment caused a marked decrease in appetite, which was ameliorated with acclimatization. Adolph confirmed this heat related anorexia with military personnel in the field (53). Although earlier reviews point out inconsistent results in studies examining the effects of heat exposure on basal metabolic rate (34), there is insufficient evidence to demonstrate conclusively that a lower BMR is at the root of the anorexia. Neither is there any reason to believe that mechanical efficiency is improved in a hot environment. In fact, Consolazio et al. (54) demonstrated that in contrast to the decreased voluntary caloric intake, the caloric expenditure to perform a standardized exercise of a moderate intensity is increased. This has been attributed to the additional thermoregulatory metabolic demand associated with heat dissipation which is superimposed onto the caloric demand of the work. A specific task is therefore performed at a greater relative intensity, increasing the demand on carbohydrate metabolism as discussed earlier. This is manifested in greater carbohydrate oxidation with acute exercise in the heat (55,56).

172. When considering the physical demands on individual soldiers, body size should be considered. The smaller individual has a greater body surface area/mass ratio, and therefore a greater relative area for heat dissipation than in larger individuals (57). Also the extra heat associated with muscular work for a given task is a direct function of body weight.

173. The overriding nutritional concern in a hot environment is maintaining the body's hydration status. Marked impairments of endurance exercise performance are already noticeable with a fluid loss corresponding to about 3% of body weight (58). Fluid requirements and suggested drinking guidelines can be found in Chapter 2 of this report.

3.8 SUMMARY

174. The body's stores of carbohydrates are limited compared to those of the other energy stores. Unfortunately, it is these limited carbohydrate stores on which muscle is most dependent for fuel as the intensity of physical exercise increases. When the intramuscular stores of carbohydrates, in the form of glycogen, are depleted subsequent exercise performance is impaired. There is direct evidence that muscle glycogen stores of military personnel are markedly depleted at the end of combat field trials. The consumption of >450 g of carbohydrate per day should facilitate adequate glycogen resynthesis. There is experimental evidence that adaptation to a calorie-dense, fat-rich, i.e. carbohydrate-poor, diet

may be possible although the time course and extent of adaptation must be clarified before such a diet can be applied.

175. There is no consistent evidence to suggest that the capacity to perform physical exercise would be enhanced by the addition of micronutrients to rations. When transporting personnel across time zones, the ingestion of l-tryptophan may be beneficial in increasing sleep time and avoiding subsequent performance impairments associated with sedatives.

176. Calorie restriction causing body weight loss of up to about 10% will not cause drastic performance impairments, if dehydration, ketosis, and hypoglycemia can be avoided. Lightweight daily rations containing 2000 kcal are therefore feasible for units for whom a reduced foodpack weight and volume would be advantageous.

177. The environmental stress of heat or altitude causes an anorexia which can result in insufficient energy and/or carbohydrate intake to maintain optimal physical performance. Cold environments, are usually associated with an increased energy consumption, probably because of the increased caloric cost of working in protective clothing and with specialized equipment. The implications of most environmental stresses are that the relative physiological demands of a given task are increased. In all likelihood the energy cost and the dependence on carbohydrates for that energy are also increased.

3.9 REFERENCES

1. Aakvaag, A., O. Bentdal, K. Quigstad, P. Walstad, H. Ronningen and F. Fonnum. Testosterone and testosterone binding globulin (TeBG) in young men during prolonged stress. Int. J. Andrology 1:22-31, 1978.

2. Rognum, T.O., F. Vartdal, K. Rodahl, P.K. Opstad, O. Knudsen-Baas, E. Kindt, W.R. Withey. Physical and mental performance of soldiers on high- and low-energy diets during prolonged heavy exercise combined with sleep deprivation. Ergonomics 29:859-867, 1986.

3. Buskirk, E.R. Energy and water requirements under conditions pertinent to military operations: an annotated bibliography. United States National Research Council, Commission on Life Sciences, Food and Nutrition Board, Committee on Military Nutrition Research, 1984.

4. United States National Research Council. Predicting Decrements in Military Performance Due to Inadequate Nutrition. National Academy Press: Washington, D.C., 1986.

5. Newsholme, E.A. and A.R. Leech. Biochemistry for the Medical Sciences. John Wiley and Sons: Chichester, 1983.

6. Lemon, P., K.E. Yarsheski and D.G. Dolny. The importance of protein or athletes. Sports Med. 1:474-484, 1984.

7. NATO Defence Research Group. Physical Fitness in Armed Forces. Final Report of Research Study Group 4 on Physical Fitness. NATO Document AC/243-D/1092, Brussels, 1986.

8. Costill, D.L. and J.M. Miller. Nutrition for endurance sport: carbohydrate and fluid balance. Int. J. Sports Med. 1:2-14, 1980.

9. Conlee, R.K. Muscle glycogen and exercise endurance: a twenty-year perspective. In: Pandolf, K.B. (ed.) Exercise and Sport Sciences Reviews. Macmillan Publishing: New York, 1977, pp. 1-28.

10. Jacobs, I., P. Kaiser, and P. Tesch. Muscle strength and fatigue after selective glycogen depletion in human skeletal muscle fibers. Eur. J. Appl. Physiol. 46:47-53, 1981.

11. Maughan, R.J. and D.C. Poole. The effects of a glycogen-loading regimen on the capacity to perform anaerobic exercise. Eur. J. Appl. Physiol. 46:211-219, 1981.

12. Heigenhauser, G.J.F., J.R. Sutton and N.L. Jones. Effect of glycogen depletion on the ventilatory response to exercise. J. Appl. Physiol. 54:470-474, 1983.

13. Young, K. and C.T.M. Davies. Effect of diet on human muscle weakness following prolonged exercise. Eur. J. Appl. Physiol. 53:81-85, 1984.

14. Costill, D.L., R. Bowers, G. Branam, and K. Sparks. Muscle glycogen utilization during prolonged exercise on successive days. J. Appl. Physiol. 31:834-838, 1971.

15. Jacobs, I., A. Anderberg, R. Schele, H. Lithell. Muscle glycogen in soldiers on different diets during military field manoeuvers. Aviat. Space Environ. Med. 54:898-900, 1983.

16. Askew, E.W., J.R. Claybaugh, G.M. Hashiro, W.S. Stokes, A. Sato, and S.A. Cucinell. Mauna Kea III: Metabolic effects of dietary carbohydrate supplementation during exercise at 4100 m altitude. US Army Research Institute of Environmental Medicine Report No. T12-87, Natick, Massachusetts, May 1987.

17. Saltin, B. Metabolic fundamentals in exercise. Med. Sci. Sports 5:137-146, 1972.

18. Costill, D.L., W.M. Sherman, W.J. Fink, C. Maresh, M. Witten, and J.M. Miller. The role of dietary carbohydrates in muscle glycogen resynthesis after strenuous running. Amer. J. Clin. Nutr. 34:1831-1836, 1981.

19. Powers, S.K. and S. Dodd. Caffeine and endurance performance. Sports Med. 2:165-174, 1985.

20. Coyle, E.F. and A.R. Coggan. Effectiveness of carbohydrate feeding in delaying fatigue during prolonged exercise. Sports Med. 1:446-458, 1984.

21. Neufer, P.D., D.L. Costill, M.G. Flynn, J.P. Kirwan, J.B. Mitchell and J. Houmard. Improvements in exercise performance: effects of carbohydrate feedings and diet. J. Appl. Physiol. 62:983-988, 1987.

22. Hargreaves. M., D.L. Costill, W.J. Fink, D.S. King, and R.A. Fielding. Effect of pre-exercise carbohydrate feedings on endurance cycling performance. Med. Sci. Sports Exercise 19:33-36, 1987.

23. Flynn, M.G., D.L. Costill, J.A. Hawley, W.J. Fink, P.D. Neufer, R.A. Fielding and M.D. Sleeper. Influence of selected carbohydrate drinks on cycling performance and glycogen use. Med. Sci. Sports Exercise 19:37-40, 1987.

24. Kark, R.M., R.E. Johnson and J.S. Lewis. Defects of pemmican as an emergency ration for infantry troops. War Med. 7:345, 1945.

25. Phinney, S.D., B.R. Bistrian, W.J. Evans, E. Gervino, and G.L. Blackburn. The human metabolic response to chronic ketosis without caloric restriction: preservation of submaximal exercise capability with reduced carbohydrate oxidation. Metabolism 32:769-775,1983.

26. van der Beek, E.J. Vitamins and endurance training: food for running or faddish claims? Sports Med. 2:175-197, 1985.

27. van der Beek, E.J., W. van Dokkum, J. Schrijver, M. Wedel and A.W.K. Gaillard. Impact of restricted vitamin intake on functional performance in man. Amer. J. Clin. Nutrition. Submitted for publication. 1987.

28. Banderet, L.E., H.R. Lieberman, R.P. Francesconi, B.L. Shukitt, R.F. Goldman, D.D. Schnakenberg, T.M. Rauch, P.B. Rock and G.F. Meadors. Development of a paradigm to assess nutritive and biochemical substances in humans: a preliminary report on the effects of tyrosine upon altitude- and cold-induced responses. In: Biochemical Enhancement of Performance (AGARD-CP-415). NATO Advisory Group for Aerospace Research and Development, 1987.

29. Spinweber, C.L. Sedating and nonsedating sleeping aids in air operations. In: Biochemical Enhancement of Performance (AGARD-CP-415). NATO Advisory Group for Aerospace Research and Development, 1987.

30. Crowdy, J.P., M.F. Haisman and H. McGavock. Combat nutrition. The effects of a restricted diet on the performance of hard and prolonged physical work. Army Personnel Research Establishment Report 2/71, Farnborough, April 1971.

31. Grande, F. Impact of food restriction on physical performance. In: see reference 2.

32. Askew, E.W., I. Munro, M.A. Sharp, S. Siegel, R. Popper, M. Rose, et al. Nutritional status and physical and mental performance of special operations soldiers consuming the Ration, Lightweight or the Meal, Ready-to-Eat military field rations during a 30-day field training exercise. US Army Research Institute of Environmental Medicine Report No. T7-87, Natick, Massachusetts, March 1987.

33. Boothby, W.M., W.R. Lovelace II and O.O. Benson. High altitude and its effect on the human body. I. J. Aeronautical Sc. 7:461-468, 1940.

34. Mitchell, H.H. and Edman, M. Nutrition and Climatic Stress. Charles C. Thomas: Springfield, Ill., 1951.

35. Askew, E.W., Claybaugh, J.R., Cucinell, S.A., Young, A.J. and E.G. Szeto. Nutrient intakes and work performance of soldiers during 7 days of exercise at 7,200 feet altitude consuming the meal, ready-to-eat (MRE) operational rations. USARIEM Technical Report No. T3-87, 1986.

36. Consolazio, C.F., L.O. Matoush, H.L. Johnson, H.J. Krzywicki, T.A. Daws and G.J. Isaac. Effects of high-carbohydrate diets on performance and clinical symptomatology after rapid ascent to high altitude. Fed. Proc. 28:937-943, 1969.

37. Nadel, E.R., I. Holmer, U. Bergh, P.-O. Astrand and J.A. Stolwijk. Thermoregulatory shivering during exercise. Life Sci. 13:983-989, 1973.

38. Hong, S. and E. Nadel. Thermogenic control during exercise in a cold environment. J. Appl. Physiol. 47:1084-1089, 1979.

39. Pugh, L.G.C.E. Cold stress and muscular exercise, with special reference to accidental hypothermia. Br. Med. J. 2:333 337, 1967.
40. Stromme, S., K.L. Andersen and R.W. Elsner. Metabolic and thermal responses to muscular exertion in the cold. J. Appl. Physiol. 18:756-763, 1963.

41. Jacobs, I., T. Romet and D. Kerrigan-Brown. Muscle glycogen depletion during exercise at 9°C and 21°C. Eur. J. Appl. Physiol. 54:335-39, 1985.

42. Brobeck, J.R. Food intake as a mechanism of temperature regulation. Yale J. Biol. and Med. 20:545-552, 1948.

43. Johnson, R.E. and R.M. Kark. Environment and food intake in man. Science 105: 378-379, 1947.

44. welch, B.E., E.R. Buskirk and P.F. Iampietro. The relation of climate and temperature to food and water intake in man. U.S. Army Medical Nutrition Laboratory, Denver, Colorado, Report No. 213, September, 1957.

45. LeBlanc, J.A. Effect of environmental temperature on energy expenditure and caloric requirements. J. Appl. Physiol. 10:281-283, 1957.

46. Welch, B.E., L.M. Levy, C.F. Consolazio, E.R. Buskirk and T.E. Dee. Caloric intake for prolonged hard work in the cold. U.S. Army Medical Nutrition Laboratory Report, Denver, Colorado, Report No. 202, March, 1957.

47. Davis, T.R.A. The influence of climate on nutritional requirements. Amer. J. Public Health 54:2051-2067, 1964.

48. Kark, R.M., R.R. Croome, J. Cawthorpe, D.M. Pell, A. Bryans, R.J. MacBeth, R.E. Johnson, F.C. Consolazio, U.L. Poulin, F.H.L. Taylor and R.C. Cogswell. Observations on a mobile arctic force. The health, physical fitness and nutrition of Exercise "Musk Ox", February-May 1945. J. Appl. Physiol. 1:73-92, 1948.

49. Roberts, D.E., J.F. Patton, J.W. Pennycook, M.J. Jacey, D.V. Tappan, P. Gray and E. Heyder. Effects of restricted water intake on performance in a cold environment. U.S. Army Research Institute of Environmental Medicine Report No. T2/84, Natick, Massachusetts, May 1984.

50. Wang, L.C.H., S.F. Paul Man and A.N. Belcastro. Metabolic and hormonal responses in theophylline-increased cold resistance in males. J. Appl. Physiol. 63:589-596, 1987.

51. Wang, L.C.H. and T.F. Lee. Substrate preference in aminophylline-stimulated thermogenesis. Life Sci. 36:2539-2546, 1985.

52. Lee, D.H.K. A basis for the study of man's reaction to "tropical climates." Queensland University Papers 1: No. 5, pp. 86, 1940.

53. Adolph, E.F. (editor) Physiology Of Man In The Desert. Interscience Publishers, Inc.: New York, 1947.

54. Consolazio, C.F., L.O. Matoush, R.A. Nelson, G.J. Isaac and J.B. Torres. USAMRNL Rep. No. 268, Denver, Colorado, 1962.

55. Fink, W.J., D.L. Costill and P.J. van Handel. Leg muscle metabolism during exercise in the heat and cold. Eur. J. Appl. Physiol. 34:183-190, 1975.

56. Young, A.J., M.N. Sawka, L. Levine, B.S. Cadarette and K.B. Pandolf. Skeletal muscle metabolism during exercise is influenced by heat acclimation. J. Appl. Physiol. 59:1929-1935, 1985.

57. Robinson, S. The effect of body size upon energy exchange in work. Am. J. Physiol. 136:363-368, 1942.

58. Saltin, B. Aerobic and anaerobic work capacity after dehydration. J. Appl. Physiol. 19: 1114-1118, 1964.

CHAPTER 4

NUTRITION AND CORONARY HEART DISEASE RISK FACTORS IN THE MILITARY POPULATION

4. 1 LIPOPROTEIN METABOLISM

178. Two organs, the liver and the gut, produce lipoproteins. After a meal containing fat the dietary triglycerides undergo digestion in the intestine to fatty acids and monoglycerides. These are absorbed by the intestinal mucosa, recombined into triglycerides and incorporated into lipoproteins called chylomicrons. The chylomicrons are secreted into the chyle, enter the systemic circulation through the thoracic duct and pass into the peripheral circulation. Here they come into contact with an enzyme named lipoprotein lipase; this enzyme hydrolyzes the triglycerides to free fatty acids and glycerol. When lipolysis is almost complete, a residual particle, called a chylomicron remnant, is released into the circulation and is cleared by the liver.

179. The liver, like the gut, produces a triglyceride-rich lipoprotein, very low density lipoprotein (VLDL). The metabolism of VLDL is similar to that of chylomicrons. The triglycerides of VLDL also undergo lipolysis by lipoprotein lipase, and VLDL remnants are released into the circulation. A major portion of VLDL remnants are contained in intermediate-density lipoprotein (IDL), VLDL remnants can have 2 fates. About half of these lipoproteins are removed by the liver. The remainder are converted to a smaller lipoprotein, low-density lipoprotein (LDL).

180. LDL is the major cholesterol-carrying lipoprotein of plasma, and it also can have 2 fates. Normally, about 70 to 75% of LDL is cleared by cell surface receptors for this lipoprotein. The liver is probably the major site of LDL clearance, but peripheral tissues also may remove a portion of circulating LDL. The remaining plasma LDL (25 to 30%) is removed by nonreceptor mechanisms (for example, nonspecific pinocytosis) in a variety of tissues.

181. Another class of lipoproteins are the high-density lipoproteins (HDL). Lipoprotein precursors are secreted by the liver and gut as cholesterol-poor particles called nascent HDL. The latter apparently take up cholesterol in peripheral tissues for transport to the liver; this process has been called "reverse cholesterol transport". The exact mechanisms by which HDL returns cholesterol ester to the liver have not been resolved. The liver may remove HDL directly, or HDL may transfer its cholesterol to VLDL where the cholesterol can later be removed by the liver in association with IDL or LDL.

182. Some of the major advances in the lipoprotein field have been the elucidation of the structure and function of the proteins, or apolipoproteins, of the lipoprotein complexes. Each apoprotein appears to have a specific function. The major "structural" lipoprotein associated

with chylomicrons is apo B-48 (small apo B), whereas that with hepatic VLDL is apo B-100 (large apo B). Both chylomicrons and VLDL contain 2 other apoproteins, apo C and apo E. The apo C class appears to be required for the activation of lipoprotein lipase. Apo E plays an important role in uptake of remnants of chylomicrons and VLDL by the liver. Apo B-100 is necessary for the structural integrity of VLDL and LDL, and it directs VLDL remnants and LDL to LDL receptors for removal. VLDL remnants are cleared more rapidly by the liver because of the presence of apo E on the surface coat; apo E enhances receptor-mediated clearance of apo B-containing lipoproteins. Apo A-I and apo A-II are the major apoproteins of HDL, and they are probably important in extraction of cholesterol from peripheral tissues and in reverse cholesterol transport.

183. The different categories of lipoproteins seemingly differ in their atherogenic potential. Chylomicrons are probably not atherogenic. They are large particles and apparently do not filter well into the arterial wall; they also contain mainly triglycerides that contribute little to the atherosclerotic plaque.

184. VLDL may be mildly atherogenic, and because VLDL is a enterogenous fraction, the various forms of VLDL may differ in their atherogenicity; small VLDL contains the most cholesterol and seemingly filters better into the arterial wall than large VLDL. IDL seems to be moderately atherogenic, and LDL is markedly so. These cholesterol-rich lipoproteins are small and readily penetrate the arterial wall. Their atherogenicity is enhanced by the presence of apo B, because this apoprotein can interact with interstitial materials of the subintimal region, leading to precipitation and sequestration of LDL cholesterol. The importance of apo B in atherogenesis is illustrated by the fact another small, cholesterol-rich lipoprotein, HDL, is not atherogenic.

4.1.1 Hypercholesterolemia

185. The most common and most dangerous form of hyperlipidemia in that associated with increases in LDL levels is hypercholesterolemia. There are several degrees of hypercholesterolemia and the risk for coronary heart disease depends on the severity of LDL increase. In the absence of other risk factors, total cholesterol levels <200 mg/100 ml (that is, LDL-cholesterol levels <125 mg/100 ml) are associated with slowly progressive atherosclerosis that generally does not produce a critical degree of coronary narrowing until late in life, if at all (1,2,3). In a condition that can be called "mild hypercholesterolemia" (total cholesterol 225 to 275 mg/100 ml) the risk for coronary heart disease is approximately twice that of cholesterol levels <200 mg/100 ml (4). In "moderate hypercholesterolemia" (total cholesterol 275 to 325 mg/100 ml), risk is increased by 2 to 4 fold, and in severe hypercholesterolemia (total cholesterol >325 mg/100 ml), risk is even greater, 4 to 8 fold higher than when cholesterol levels are <200 mg/100 ml.

186. Most forms of hypercholesterolemia appear to be related to a decrease in receptor-mediated clearance of LDL. The mechanisms responsible

for the decrease in receptor activity are variable, but the metabolic consequences are similar. Two factors can cause an increase in LDL levels with receptor deficiency (5). First, clearance of LDL is decreased, and second, a reduced hepatic uptake of VLDL remnants (IDL) leads to increased conversion of IDL to LDL. Thus, both over production of LDL and decreased catabolism of LDL elevate LDL concentrations.

187. The most common cause of severe hypercholesterolemia is a condition called familial hypercholesterolemia. The cause of this disorder is defect in LDL receptors (6). Most affected patients have inherited only half the normal number of LDL receptors, and their LDL levels consequently are about twice normal. As indicated above, production of LDL is high and clearance of LDL is low. Clinical atherosclerotic disease is common in the 30s and early 40s in men and in the late 40s and 50s in women.

188. From 3 to 5% of the adult population has moderate hypercholesterolemia (total cholesterol 275 to 325 mg/100 ml). The causes of moderate hypercholesterolemia are not well defined. Excessive intakes of saturated fats and cholesterol, together with obesity, probably contribute to moderate hypercholesterolemia in many patients. In most patients, however, genetic factors are important as well. LDL receptor activity is probably depressed, but is not clear whether the defect resides in regulation of receptor synthesis or in the structure of the receptors themselves.

189. Patients with moderate hypercholesterolemia should be treated first with dietary change; if the response is not adequate, as frequently it is not, drugs can be used as well. The value of drug therapy in moderate hypercholesterolemia is illustrated by the recent Lipid Research Clinic Coronary Primary Trial (LRC CPPT) (7,8). This study tested the effects of cholestyramine in a large group of men with moderate hypercholesterolemia. This double-blind study lasted for 7 years, and upon completion it was found that patients receiving the active drug had a significant decrease in new coronary heart disease. Although sequestrant therapy may normalize LDL levels in some patients, all patients should be urged to maintain rigid control of their diet. Also, in some patients whose LDL levels are resistantly high, 2 drugs may be required.

190. Most patients with coronary heart disease have mild hypercholesterolemia (total cholesterol 225 to 275 mg/100 ml). Most investigators believe that mild elevations of LDL are mainly due to diet, but genetic factors also can be involved. Dietary factors (for example, cholesterol and saturated fatty acids) seemingly reduce activity of LDL receptors. Treatment of mild hypercholesterolemia therefore is largely dietary. The dietary approach requires a progressive decrease in intakes of total fat, saturated fats and cholesterol (9).

4.1.2 Hypertriglyceridemia

191. The relation between plasma triglycerides and atherosclerotic disease is less well defined than for cholesterol. As indicated above,

chylomicrons and VLDL are not generally considered highly atherogenic. However, a high proportion of patients with coronary disease have hypertriglyceridemia. The reason for this apparent discrepancy has not been resolved completely, but available evidence suggests that some forms of hypertriglyceridemia impart increased risk for coronary disease while others may not.

192. As a general rule, hypertriglyceridemia can arise in 2 ways, as defective clearance of triglyceride-rich lipoproteins or by over production of VLDL. Current data suggest that the former may not be an atherogenic defect while the latter probably is.

4.1.3 Age and Distribution of Lipids and Lipoproteins

193. Comparisons among age groups reveals a sharp increase in both total and low-density lipoprotein (LDL) cholesterol levels during adulthood. This age related increase represents an atherogenic pattern characteristic of Westernized society. It is interesting that somewhat marked changes were also noted in levels of lipids and lipoproteins between childhood and adolescence: the pattern revealed was not one of simple monotonic increase.

194. The relation between cholesterol levels and gender changed with age and included 2 crossover points. Both total and LDL cholesterol values were higher in females during childhood, while high-density lipoprotein (HDL) cholesterol values were higher in male children. The first crossover point for total cholesterol level occurred in the early to mid-20s, and resulted in male excess with a plateau observed during middle age. Total and LDL cholesterol levels continued to increase for females and the second crossover appeared at the approximate age of 50, after which values were higher in women than in men. The age pattern of HDL cholesterol was quite different: higher male values in childhood were followed by a decrease that brought them to below female values throughout adulthood.

4.1.4 Correlation of HDL with Total and LDL Cholesterol

195. Measures of the correlation of HDL with total cholesterol vary with age and sex. Although the correlation of these 2 components of plasma cholesterol is close to zero in young adulthood, there is a positive association in childhood and an increasingly positive association with age over 25 years. HDL cholesterol generally is more independent of LDL cholesterol, as reflected in the small magnitude of the correlation between the 2 lipoprotein cholesterol fractions. There is a small negative correlation in childhood and young adulthood that increases with age and comes close to zero beginning in middle age. Because HDL and LDL cholesterol levels are independent of each other, they have the potential for additive information predictive of coronary heart disease (CHD).

4.1.5 Determinants of Total, LDL and HDL Cholesterol Levels

196. The major correlates, are dietary and genetic factors. The Family Study has provided documentation of significant similarities in lipid and lipoprotein levels among first-degree relatives (10) and suggests that both genetic and cultural factors contribute to heritability, although genetic contributions appear to be the primary determinant. In addition to genetic determinants and dietary factors, including total calories, calories from fats and cholesterol intake, such demographic considerations as age, sex and race; anthropometric factors such as the weight-height index; and behavioural and medical factors such as smoking, exercise and alcohol habits also contribute to cholesterol levels.

4.2 SERUM CHOLESTEROL AS A RISK FACTOR FOR ISCHAEMIC HEART DISEASE (IHD)

197. Cholesterol is a prominent component of the arterial atheromatous deposits. A natural question is whether the level of cholesterol in the blood is related to the likelihood of developing excessive deposits of cholesterol and other material in the artery walls, and in turn whether serum cholesterol is related to coronary artery disease. We reviewed three studies to make it clear.

4.2.1 The Seven Countries Study

198. This study started in 1955 and examined populations from different countries with different ischaemic heart disease rates, cultures and habits. Men from one to three communities in each of seven countries: Japan, the Netherlands, Yugoslavia, Greece, Italy, Finland and the United States were compared, 11,000 men aged 40-59 were included in the study. The project was divided into a prevalence and an incidence study. They first recorded disease prevalence at the beginning of the study and measured several variables concurrently, such as blood pressure, height, weight, age, serum cholesterol, smoking status, electrocardiogram (ECG), and skinfold thickness. These variables could at least potentially be linked etiologically to cardiac status or to the atherosclerotic process. Large differences in IHD incidence rates were found between different countries serum cholesterol and some dietary related variables were those most consistently associated with IHD rates. The Seven Countries incidence data support a causal hypothesis between serum cholesterol and IHD risk; they do not prove it. We must seek further evidence before asserting the consistency and plausibility of this hypothesis (11).

4.2.2 The Ni-Hon-San Study

199. Three cohorts of Japanese men were studied in three different environments: southern Japan, Hawaii and San Francisco. Mortality from IHD increased consistently from Japan to Honolulu and from Honolulu to San Francisco: this was true for all three age ranges considered. In the two US locations where IHD rates are higher, serum cholesterol levels

approximate to those of white Americans but are substantially lower in Japan, thus, the data are consistent with the idea that serum cholesterol levels, or something closely linked to them, are causally related to IHD (12).

4.2.3 The Framingham Study

200. This was the first major longitudinal study following a representative sample of a population 30-60 years old, for 20 years.

201. As with other studies, many physiological and life-style variables proved to correlate with the risk of developing coronary heart disease. Among them was again, serum cholesterol, for both men and younger women at least, those who have moderate to high levels of serum cholesterol are at higher risk for developing IHD. From blood cholesterol levels ranging from 150 to 260 mg/dl there is about a 3 fold increase in risk for men and about a 1.5 fold increase in risk for younger women. This range of cholesterol is below that of type II hyperlipidemic individuals and these are commonly accepted as "normal" values.

202. There has been some controversy regarding the optimal level of serum cholesterol and in particular whether there is a moderately low level of serum cholesterol below which risk reduction for IHD does not occur. Optimum is at least as low as 200 mg/dl and probably lower. Cigarette smoking and hypertension were two other variables that significantly predict an increased risk of IHD (13,14,15).

4.2.4 Prediction Using Different Forms of Serum Cholesterol

203. In recent years we have been able to measure the individual lipoprotein particles in which blood cholesterol is carried: high density (HDL), low-density (LDL) and very low-density lipoproteins (VLDL). LDL is the damaging form, HDL is negatively associated with IHD. A powerful predictor of IHD, HDL levels average 10-15 mg/dl higher in women than in men. Total serum cholesterol loses much predictive power in old age, but when it is divided into HDL and LDL cholesterol, both retain individual predictive ability, even in the elderly (16).

204. In this situation, where one factor is apparently protective and the other detrimental, the factors can be combined into a single ratio of LDL to HDL. As this ratio rises by either increased LDL, decreased HDL, or both IHD should rise (17,18). Total cholesterol/HDL cholesterol ratio correspond to change in the relative risk of IHD. LDL cholesterol seems to be determined by dietary factors, obesity, age and heredity. The HDL cholesterol levels are determined by obesity, exercise level, sex hormones, alcohol consumption and cigarette smoking.

205. Most researchers accept LDL cholesterol as an important risk factor in IHD. It is the major constituent of blood cholesterol and has determinants similar to those of total blood cholesterol. This suggests

that evidence from older studies implicating total blood cholesterol as a risk factor can now be largely attributed to LDL cholesterol. However, some do not believe that HDL cholesterol has been established as a causal risk factor for IHD; rather they think the relationship may represent a statistical association in which HDL acts as a surrogate for some other causal variable. This possibility is raised by some inconsistencies found particularly in international comparisons. In general, such comparison do not clearly relate national average values of HDL cholesterol to IHD rates.

206. The explanation may be that while low fat consumption is usually associated with low HDL cholesterol levels in different such groups (19) it is also associated with a reduction in total cholesterol (due to the effect on LDL). The effect on the total cholesterol/HDL ratio is variable, thus raising the possibility that optimal values of this measure for the U.S. may not apply universally. Such apparent inconsistencies in international comparisons also occur with the variables of cigarette smoking and exercise and may only reflect the complex multivariate nature of the disease.

207. The apolipoproteins are the structural proteins of the lipoprotein particles. Different particles have distinctive proportions of these different apolipoproteins. As the proteins are intimately associated with the lipids and in addition often in activate enzymes involved in phases of lipid transport, it is natural to ask whether changes in concentrations of these proteins may affect atherogenesis. Epidemiological studies indicate that both apolipoprotein A1 associated particularly with the HDL particle and apolipoprotein B (associated with the LDL particle) are significant predictors of disease, perhaps even better than the levels of the associated HDL or LDL cholesterol.

4.2.5 Blood Lipid Levels and Pathological Coronary Conditions

208. As obstructed coronary arteries are a causal factor of IHD, several investigators have tried to relate lipid levels directly to the severity of such conditions using coronary angiography and postmortem examinations.

209. Significant relationship were found between coronary obstructive lesions and serum total cholesterol, HDL cholesterol and the ratio total/HDL cholesterol (20,21).

4.3 RELATIONSHIP BETWEEN DIET AND SERUM CHOLESTEROL

210. Diet is a very complex variable, yet probably one of the most important in IHD research (22). Many different foods and nutrients make up our diet, mixed in varying proportions producing a vexing measurement problem, particularly in population research. Perhaps the ideal would be to collect a fixed proportion of all food eaten, for laboratory analysis. However, this is very expensive and does not overcome the problem of subjects consciously or subconsciously changing their diets during the few

days of investigation. A related but less accurate way of assessing diet is to have the subjects keep a 3 or 7 day food diary.

211. Food Frequency Recall, relies heavily on subject's memory and perception of the month a particular food is eaten, rather than amounts of food, and may seem rather crude. However, it has the advantage of simplicity and of allowing recall over longer time periods.

212. Most of the fat in human diets is in the form of fatty acids either in combination with glycerol or with phosphate containing molecules (phospholipids). Acids of chain lengths of 12, 14, 16 and 18 carbons are the most common, although shorter and longer chains do occur. The following discussion deals with the medium chain and a few longer chain acids, as those best known to influence serum cholesterol levels or platelet function.

213. The fatty acids are divided into three groups, those that are completely saturated with hydrogen and thus have no double bounds, those that have one double bond (monounsaturated), and those that have two or more double bounds (polyunsaturated). The major saturated dietary fatty acids are C12, C14, C16, C18; the major dietary monounsaturated acids is 18:1; and the major dietary polyunsaturated acids are 18:2, 18:8, 20:4, 20:5. The polyunsaturated fatty acids are precursors for corresponding families of prostaglandins, which are potent tissue hormones influencing many aspects of human physiology including blood pressure, vascular reactivity and platelet function.

4.3.1 Fat Consumption Related to Serum Cholesterol

214. The medium chain saturated fatty acids (C12, C14, C16) raise serum cholesterol. Stearic acid does not affect serum cholesterol levels.

215. Hydrogenated vegetable fats act as saturated fatty acids by raising serum cholesterol to a similar degree as the naturally occurring saturated fatty acids. Medium chain polyunsaturated acids of the n-6 family depress serum cholesterol levels to half the extent that equivalent quantities of the saturated fatty acids mentioned above raised these levels. Thus it is clear that foods with similar quantities but differing qualities of fat can affect serum cholesterol very differently, but predictably.

216. How saturated fatty acids raise serum cholesterol is even less well understood. The action may be on cholesterol absorption, hepatic cholesterol production or cholesterol excretion from the bowel.

217. Dietary cholesterol is known to influence hepatic cholesterol production via a feedback loop. Excess caloric intake and obesity apparently provoke increased endogenous hepatic cholesterol formation (23, 24,25,26,27).

4.3.2 Effects of Vegetables and Fruits on Serum Cholesterol Levels

218. Vegetarians consistently show markedly lower serum cholesterol levels than the general population. This is undoubtedly attributable in part to their lower intake of saturated fats and cholesterol.

219. Dietary fibre is a heterogenous group of complex plant polysaccharides, possessing the common feature that they are not absorbed from the bowel lumen. Of the various dietary fibers (pectin, cellulose, lignin, gums) pectin and gums clearly lower serum cholesterol.

220. The mechanisms by which dietary fibre reduces the serum cholesterol are partially understood. Dietary fibre binds sterols (dietary cholesterol and bile acids) in the gut, increasing their excretion. Fibre also forms gels in the small bowel, possibly reducing the surface area of the intestinal contents exposed to the absorptive mucosa (28,29,30).

4.3.3 Milk and Protein

221. The question of what effects milk and protein have on serum cholesterol is a controversial one. The fact that milk fats are largely saturated would suggest a serum cholesterol raising effect, but several studies have demonstrated that low-fat or skimmed milk reduces serum cholesterol.

222. Yogurt and whole milk at least do not seem to raise blood cholesterol, which is contrary to expectations on fat content. This may imply the presence of an unidentified cholesterol lowering substance in milk products (31,32).

4.4 DIET AND ISCHAEMIC HEART DISEASE

223. Diet influences serum cholesterol which has an effect on the risk of ischemic heart disease (IHD). It would then seem obvious that diet will influence the risk of ischemic heart disease.

4.4.1 Epidemiology Studies

224. When the diet-ischemic heart disease relationship is investigated directly, the variable are farther apart in the postulated causal sequence than in the diet-serum cholesterol relationship. The diet-IHD relationship presents difficult problems of interpretation. The abrupt decline in IHD mortality in the Scandinavian countries during the Second World War correlated with dramatic dietary changes but also occurred concurrently with non-dietary changes. The Seven Countries Study showed an impressive relationship between saturated fat consumption and IHD mortality. The relationship between dietary variables and IHD mortality in the three locations of the NI-HON-SAN Study is also in the hypothesized direction. Studies within a single population are difficult to interpret.

The Framingham Study could find no relationship between diet and IHD (33, 34,35,36,37,38).

225. No relationship was found between the percentage of calories as fat of any kind and risk. This is hardly surprising in a study that could detect no relationship between dietary fat and serum cholesterol even though such an effect is established (39).

226. Some intra-national epidemiologic studies do show an important relationship between diet and IHD (Western Electric Study, London Transport drivers).

4.4.2 Role of Platelets

227. There are two groups of chemicals that affect platelet activation, prostacyclins and the thromboxanes, both members of the prostaglandin family. Prostacyclins are produced by the endothelium; they inhibit platelet activation and also promote vasodilatation. Thromboxanes are produced by platelets during activation and tend to promote further platelet activation as well as vascular spasm. The most important members of these prostaglandin families are the prostacyclin PGI_2 and thromboxane A_2. Both are metabolites of arachidonic acid, a long-chain polyunsaturated fatty acid. Dietary linoleic acid can be converted to arachinodic acid, although the conversion is slow and incomplete - there is some evidence that dietary linoleic acid may directly inhibit the formation of thromboxane A_1 from arachidonic acid and so be beneficial by altering the balance in favor of protacyclin PGI_2 (40,41).

4.4.3 Diet and Platelet Function

228. The influence of diet on platelet function has been established by studies using saturated fatty acids, linoleic acids, and the longer chain polyunsaturated acids found in marine oils. Small group feeding experiments with platelet function as the end point consistently show that fats containing linoleic acid reduce platelet aggregability, and saturated fatty acids probably do the reverse (42,43).

4.4.4 Regression of Atherosclerosis by Dietary Means

229. The possible resolution of obstructive atherosclerotic coronary artery lesions under the influence of diet has been debated for many years. The possibility of regression of lesions should therefore be of vital interest.

230. Is there any evidence that human atherosclerosis might be reversible? They are three studies: Malinow (1981) - the Leiden intervention trial and Amstrong (1976) who indicate highly significant associations between changes in serum total/HDL cholesterol radios and lesion growth. (44,45,46,47,48).

4.5 CHD FACTORS IN THE MILITARY POPULATION

231. We reviewed the military medical literature from the NATO countries; there are many studies very similar to the civilian conclusions in 3 countries Great-Britain, USA, Canada. The other countries have only partial epidemiologic papers. We report here a British and a Canadian study that gives a good relationship and comparison to other papers.

4.5.1 United Kingdom

232. A study was carried out in which mortality from coronary heart disease during 1973 - 1977 in men aged under 55 years in the British army was compared with that in men in the civilian population (49). An inverse relation was found between mortality from coronary heart disease and rank in the army similar to that seen among the civilian social classes, but soldiers aged under 40 years had a significantly higher mortality than their civilian counterparts irrespective of the civilian's social classes. Correspondingly, officers had a significantly lower mortality, which suggests that strenuous exercise and other exigencies of military life, per se, with the possible exception of cigarette consumption, are not to blame.

233. Possibly the extremes of risk in the army are due mainly to factors associated with the identification of subgroups of high and low risk within the social classes and to the higher prevalence of cigarette smoking among soldiers.

234. Army social habits differ considerably in some respects from those of civilians. Servicemen are more likely to undertake strenuous physical exercise, and all ranks must perform a minimum of physical tests. While exercise is reputed to raise the concentration of high-density lipoprotein, (50) its value in protection from coronary heart disease is still controversial (51,52).

235. Similarly, the role of regular exercise in precipitating a coronary event in those at risk is also not clear (53,54,55). The increased mortality among soldiers is unlikely to be due to strenuous exercise since there is no similar increase among officers. The prevalence of cigarette smoking is higher among soldiers than civilians, and per caput consumption is also greater (56).

236. This may be a factor in the soldiers' higher mortality. No similar data are available for officers, though anecdotally, their consumption is much less. Differences in diet may be relevant, but 53 % of soldiers are married and eat food similar to any other British household. Army catering, in offering a large choice of menus, reflects social preference, so that unmarried soldiers eat normal British diet (57). Social stresses peculiar to army life include moving house frequently, periods of separation from spouse and family, and the Northern Ireland campaign. The effects of military discipline are more difficult to assess since, although authority is more overt, there is an increased security of employment and housing in the Service and a strong fraternal bond in the

regimental system.

237. Thus British soldiers under the age of 40 years represent a high-risk group and officers a low-risk group for coronary heart disease. The decrease in mortality with increase in rank in the army is similar to the decrease in mortality with increase in social class seen among civilians. Possibly the extremes of risk in the army are due mainly to factors associated with the identification of subgroups of high and low risk within the social classes and to the higher prevalence of cigarette smoking among soldiers.

4.5.2 Canada

238. The Canadian study of Lewis, Brown an Pope, studied 92 members of the 1981-1982 Command and Staff College course (CFCSC). Each participant received a comprehensive medical evaluation, including medical history, physical examination, fasting serum chemistries and an maximal exercise treadmill test with 12 lead ECG recorder. A standard Framingham CAD risk index was computed and maximal aerobic power (VO_2 max) was measured.

239. The students do not appear to be excessively prone to CAD as indicated by standard AHA risk factors, lipid profiles, or aerobic fitness levels. The high prevalence of positive family histories for CAD may indicate a genetic predisposition to disease.

240. Review of AHA standard risk factors for this group did not reveal any particular pathological trends, when the factors were examined either separately or combined together in the relative risk determination. The low prevalence of cigarette smokers (24%), the lack of hypertension, and the moderately low mean total cholesterol (214 $mg.dl^{-1}$) would seem to augur well for this population, since these three major factors are believed to correlate most strongly to CAD risk (58).

241. Examination of CFCSC lipid profiles is reassuring. Values were compared to those provided by Heiss et al. (59) from the LRC prevalence study, which compiled results from 10 clinics in the U.S. and Canada from 1971-76. Although CFCSC mean total cholesterol is 8% higher than the LRC mean, HDL cholesterol (the "beneficial" fraction) is higher, while LDL levels are similar.

242. Favourable associations between reduced CAD risk and aerobic capacity (presumably resulting from regular aerobic exercise) do exist (60, 61), but no direct benefit has been proven. The percentage of CFCSC subjects involved in regular aerobic exercise (33%) is higher than seen in other studies such as Nora's Colorado control group (62) at 12% and Lambert's Massachusetts survey (63) at 28%. Several subjects who normally enjoy the benefits of serious exercise stated that the lack of facility at CFCSC and/or course demands on free time precluded any significant regular physical activity. The number of regular exercisers, then, is probably considerably higher than 33%. The mean VO_2 max of 42 $ml.kg^{-1}.min^{-1}$ is considered "good for that age" by DCIEM standards (64), and compares

favourably with USAF data from Wolthuis (65), where a median VO_2 max of approximately 36 $ml.kg^{-1}.min^{-1}$ was reported for a healthy population aged 35-44 years. Only 15% of the CFCSC group recorded an aerobic capacity considered "fair" (VO_2 max < 35 $ml.kg^{-1}.min^{-1}$, indicating that the majority of subjects could be considered aerobically "fit".

243. Exercise-induced ECG repolarization changes may indicate existent CAD, although test sensitivity is greatly limited in asymptomatic populations (66). The incidence of positive GXT's (9%) in this review is in keeping with studies of other similar age groups (67). Note that the GXT was utilized here to measure aerobic capacity, not to screen for CAD; the 12-lead ECG was applied as a safety monitor. Data from Forrester and Diamond (66) indicates that the probability of CAD existing in a 35-year asymptomatic male with a positive GXT, can be as low as 1 %. Hickman's study (67) suggested that even among USAF aircrew aged greater than 37 years, intensive follow-up asymptomatic positive GXT's is not cost-effective. Where CFCSC subjects showed a classic ischaemic response to the GXT, however, specialist review was organized. If the latter clinical appraisal was unremarkable, and if no major CAD risk factor was found, the positive GXT was considered false positive without further testing.

244. A positive family history of CAD may represent genetic predisposition to disease or a familial clustering of learned behaviours or environmental conditions. When observed in first degree relatives, it may correlate strongly with disease probability (62, 68, 69), although some studies note only weak associations (70). CFCSC family histories appear to be significant (46% positive for CAD) and would better describe a group of CAD patients, rather than a supposedly "normal" population. Nora's study (62), for example, reports only 18% of subjects in a control group with a positive family history for CAD, while 61%, of his patients (all of whom had already experienced an MI), recorded a positive family history.

245. Lambert's recent survey (63) reported that persons of higher Educational/financial status were demonstrating healthier lifestyle habits (less smoking, less robust alcohol consumption, more exercise, less overweight). Lynch and Oelman (49) examined CAD mortality rates in the British Army and found that officers suffered less risk than all civilians, who in turn suffered less risk than British soldiers; mortality also tended to increase with decreasing military rank. Bardsley's review (71) presents several studies which show decreasing socio-economic status as a significant risk factor not only for CAD, but for morbidity, mortality and disability in general. High CAD rates might seem curious, therefore, among the CFCSC population, who certainly represent a "white collar" group, and who seem to be successfully incorporating risk-reducing behaviours into their life-styles. The role of genetic or familial influences defeating life-style effects may be considerable in this population.

246. Finally, responses to stress should probably be examined in this junior executive population. Type A behaviour pattern, unfortunately not examined here, is well known as a separate CAD risk factor, not only in the pathogenesis of atherosclerosis, but also in the precipitation of acute

cardiac events. This phenomenon may be particularly relevant in those selected for CFCSC, in that the time-conscious, driven, aggressive Type A often produces a superior professional output, despite the associated physical or social sacrifices.

4.6 SUMMARY

247. The Lipoprotein different pathways Metabolism are reviewed. The different categories of lipoproteins differ in their atherogenic potential. The most common and dangerous form of hyperlipidemia is hypercholesterolemia. Hypertriglyceridemia relation to atherosclerotic disease is less well defined.

248. Significant relationship were found between coronary obstructive lesions, serum total cholesterol, HDL cholesterol and the ratio total/HDL cholesterol.

249. International studies support the predicted relationship between diet and coronary heart disease. Clinical trials using diet as the primary prevention give positive and consistent results demonstrating a reduction in coronary heart disease.

250. CHD risk seems to be the same in the civilian and the military population where smoking habits and type A psychological pattern are greater.

4.7 CONCLUSIONS

251. International comparisons support the predicted relationship between, diet and IHD. However, intra-national epidemiologic studies give mixed results.

252. Clinical trials of diet as primary prevention give consistent positive results. A reduction in IHD events is seen; a reduction in total mortality is not proven, as these studies were generally not designed to adequately investigate this question.

253. Platelet function probably has a major role to play in atherogenesis, the production of angina, infarction and sudden death.

254. Platelet function is seriously affected by 2 classes of prostaglandins, the prostacyclins and the thromboxanes. Prostacyclin is antiaggregatory and the thromboxanes are proaggregatory.

255. Platelet function and prostaglandin production are partially under dietary control, with saturated fatty acids being proaggregatory and polyunsaturated vegetable fatty acids being antiaggregatory.

256. Regression of atherosclerosis by dietary means is unproven; the necessary studies have not been performed although there is suggestive evidence from studies of both human and nonhuman primates.

4.8 REFERENCES

1. Keys A. Coronary heart disease in seven countries. Circulation 1970; 41: suppl 1:1 - 1 - 1 - 211.

2. Goldbourt U, Medalie JJ, Neureld HN: Clinical myocardial infarction over a five-year period. III. A multivariate analysis of incidence, the Israel Ischemic Heart Disease Study. J Chronic Dis 1975; 28: 217.

3. Pooling Project Research Group Relationship of blood pressure, serum cholesterol, smoking habit, relative weight, and ECG abnormalities to incidence of major coronary events: final report of the pooling project. J Chronic Dis 1978; 31: 201 - 306.

4. Gordon T, Castelli WP, Hjortland MC, Kannel WB, Dawber TR: Predicting coronary heart disease in middle-aged and older persons. The Framingham Study. JAMA 1977; 238: 497.

5. Brown MS, Goldstein JL: Lipoprotein receptors in the liver: control signals for plasma cholesterol traffic. J Clin Invest 1983; 72: 743-747.

6. Goldstein JL, Brown MS. Familial hypercholesterolemia. In: Stanbury JB, Wyngaarden JB, Fredrickson DS, Goldstein JL, Brown MS, eds. The Metabolic Basis of Inherited Disease, 5th ed. New York: McGraw-Hill, 1983: 672 - 713.

7. The Lipid Research Clinics Coronary Primary Prevention Trial results. I. Reduction in incidence of coronary heart disease. Lipid Research Clinics Program. Lipid Metabolism-Atherogenesis Branch. National Heart, Lung, and Blood Institute. JAMA 1984; 251: 351 - 364.

8. The Lipid Research Clinics Coronary Primary Prevention Trial results. II. The relationship of reduction in incidence of coronary heart disease to Atherogenesis Branch. National Heart, Lung, and Blood Institute. JAMA 1984; 251: 365 - 374.

9. American Heart Association, 1978.

10. Namboodiri KK, Green PP, Kaplan EB, Tyroler HA, Morrison JA, Chase GA, Elston RC, Rifkind BM, Glueck, CJ. Family aggregation of high-density lipoprotein cholesterol: collaborative Lipids Research Clinics Family Study. Arteriosclerosis 1983; 3: 616 - 626.

11. Keys A: Seven Countries. A Multivariate Analysis of Death and Coronary Heart Disease. Cambridge, Mass, Harvard Univ Press, 1980b.

12. Kagan A, McGee DL, Yanok K, et al: Serum cholesterol and mortality in a Japanese-American population. The Honolulu Heart Program. Am J Epidemiology 114: 11, 1981.

13. Dawber TR: The Framingham Study. The Epidemiology of Atherosclerotic Disease. Cambridge, Mass, Harvard University Press, 1980, p.163.

14. Connor WE: Cross-cultural studies of diet and plasma lipids and lipoproteins, in Lauer RM, Shekelle RB (eds): Childhood Prevention of Atherosclerosis and Hypertension. New York, Raven Press, 1980, p.99.

15. Kannel WB, Gordon T: The Framingham Study. An Epidemiologic Investigation of Cardiovascular Disease. Coronary heart disease, atherothrombotic brain infarction intermittent claudication. A multivariate analysis of some factors related to their incidence: 16 year follow-up. Appendix B. Us Government Printing Office, Washington, DC, 1971.

16. Kannel WB, Castelli WP, Gordon T, et al: Serum cholesterol, lipoproteins, and the risk of coronary heart disease. Ann Intern Med 74: 1, 1971.

17. Lipid Research Clinics Program Epidemiology Committee: Plasma lipid distributions in selected North American populations. The Lipids Research Clinics Program Prevalence Study. Circulation 60: 427,1979.

18. Lipid Research Clinics Study Group: The Lipid Research Clinics Population Studies Data Book. vol 1. The Prevalence Study, NIH publication 80-1527. Bethesda, Md, US Dept of Health and Human Services, 1980.

19. Mann GV, Pearson G, Gordon T, et al: Diet and cardiovascular disease in the Framingham Study. I. Measurement of dietary intake. Am J. Clin Nutr 11: 200,1962.

20. American Heart Association: Risk factors and coronary disease, committee reports. Circulation 62: 449 A, 1980.

21. Bierenbaum ML, Fleischmab AI, Green DP, et al: The 5-year experience of modified fat diets on younger men with coronary heart disease. Circulation 42: 943,1970.

22. Anderson JT, Grande F, Keys A: Cholesterol-lowering diets. J Am Diet Assoc 62: 133,1973.

23. Anderson JT, Grande F, Keys A: Independence of the effects of cholesterol and degree of saturation of the fat in the diet on serum cholesterol in man. Am J Clin Nutr 29: 1184, 1976.

24. Anderson JT, Jacobs DR, Foster N, et al: Scoring systems for evaluation of dietary pattern effect on serum cholesterol. Prev Med 8: 525, 1979.

25. Bang HO, Dyerberg J: Plasma lipids and lipoproteins in Greenlandic West Coast eskimos. Acta Med Scand 192: 85,1972.

26. Bang HO, Dyerberg J, Hjorn N: The composition of food consumed by Greenland eskimos. Acta Med Scand 200: 69,1976.

27. Grande F, Anderson JT, Keys A: Diets of different fatty acid composition producing identical serum cholesterol levels in man. Am J Clin Nutr 25: 53, 1972.

28. Hardinge MG, Crooks H, Stare FJ: Nutritional studies of vegetarians' dietary and serum levels of cholesterol. J Clin Nutr 2: 83,1954.

29. Jenkins DJA, Newton C, Leeds AR, et al: Effect of pectin, guar gum, and wheat fibre on serum-cholesterol. Lancet 1: 1116,1975.

30. Trowell H: Dietary fibre, ischaemic heart disease and diabetes mellitus. Proc Nutr 32: 151,1973.

31. Farris RP, Frank GC, Webber LS, et al: Influence of milk source on serum lipids and lipoproteins during the first year of life, Bogalusa Heart Study. Am J Clin Nutr 35: 42, 1982.

32. Howard AN, Marks J: Hypocholesterolaemic effect of milk. Lancet 2: 255, 1977.

33. Arntzenius AC, Kromhout D, Kempen N, et al: Effect of diet on total cholesterol/HDL-C ratio in patients of Leiden Regression Trial. Circulation 68 (suppl 3): 226, 1983.

34. Beaglehole R, La Rosa JC, Heiss G et al: Serum cholesterol, diet, and the decline in coronary heart disease mortality. Prev. Med. 8: 538,1979.

35. Castelli WP, Abbott RD, Mc Namara PM: Summary estimates of cholesterol used to predict coronary heart disease. Circulation 67: 739, 1983.

36. Ehnholm C, Huttunen JK, Pietinen P, et al: Effect of diet on serum lipoproteins in a population with a high risk of coronary heart disease. N Engl J Med 307: 850,1982.

37. Garrison RJ, Wilson PW, Castelli WP, et al: Obesity and lipoprotein cholesterol in the Framingham Offspring Study. Metabolism 29: 1053,1980.

38. Kannel WB, Gordon T: The Framingham Study. An Epidemiologic Investigation of Cardiovascular Disease. Coronary heart disease, atherothrombotic brain infarction intermittent claudication. A multivariate analysis of some factors related to their incidence: 16 year follow up. Appendix B. Us Government Printing Office, Washington, DC, 1971.

39. Noppa H, Bengtsson C, Wedel H, et al: Obesity in relation to morbidity and mortality from cardiovascular disease. Am J Epidemiol 111: 682,1980.

40. Andersen P, Arnesen H, Hjermann I: Hyperlipoproteinaemia and reduced fibrinolytic activity in healthy coronary high risk men. Acta Med Scand 209: 199,1981.

41. Braunwald E, Friedewald WT, Furberg CD(eds): Proceedings of the Workshop on Platelet-active Drugs in the Secondary Prevention of Cardiovascular Events. Circulation 62 (suppl 5): 1,1980.

42. Mehta J, Mehta P: Role of blood platelets and prostaglandins in coronary artery disease. Am J Cardiol 48: 366,1981b.

43. Mehta J, Mehta P: Significance of platelet function and thromboxane B_2 levels across the human myocardial vascular bed in man. Acta Med Scand, suppl 651, p.111,181c.

44. Hartley LH, Sherwood J, Herd JA: Weight loss, serum lipid reduction, and lessening of exercise-induced ischemia by dietary restriction of lipids. Circulation 64 (suppl 4): 83,1981.

45. Heiss G, Haskell W, Mowery R, et al: Plasma high-density lipoprotein cholesterol and socioeconomic status. The lipid Research Clinics Program Prevalence Study. Circulation 62 (suppl 3): 108,1980b.

46. London Research Group: Low-fat diet in myocardial infarction. A controlled trial. Lancet 2: 501,1965.

47. Ramsdale DR, Bray CL, Beton DC, et al: Serum Lipids as indicators of occult coronary disease assessed by angiography. Am Heart J 107: 811,1984.

48. Pearson TA, Bulkley BH, Achuff SC, et al: The association of low levels of HDL cholesterol and arteriographically defined coronary artery disease. Am J Epidemiol 109: 285,1979.

49. Lynch, P. and B.J. Oelman. Mortality from Coronary Heart Disease in the British Army Compared to the Civil Population. Br. Med. J. 283: 6288, 405-407, 8 August 1981.

50. Miller NE, Rao S, Lewis B, Bjorsvik G, Myhre K, Mjos OD. High-density lipoprotein and physical activity. Lancet 1979; i:111.

51. Morris JN, Everitt MG, Pollard R, Chave SPW. Vigorous exercise in leisure time; protection against coronary heart disease. Lancet 1980; ii:1207-10.

52. Jarrett RJ. Exercise and the heart. Lancet 1981; i:36.

53. Opie LH. Sudden death and sport. Lancet 1975; i:263-6.

54. Lynch P. Soldiers, sport and sudden death. Lancet 1980; i:1235-7.

55. Yater WM, Traum AH,Brown WG, Fitzgerald RP, Geisler MA, Wilcox BA. Coronary artery disease in men 18 to 39 years of age. Am Heart F 1947; 36: 334-73.

56. Crowdy JP, Sowden RR. Cigarette smoking and respiratory ill-health in the British Army. Lancet 1975; i:1232-4.

57. Crowdy JP. The soldiers' food. Practitioner 1974; 212:560-9.

58. Stamler, Jeremiah. Research Related to Risk Factors. Circulation 60: 7, 1575-1586, December 1979.

59. Heiss, Gerado et al. Lipoprotein-Cholesterol Distributions in Selected North American Populations: The Lipid Research Clinics Program Prevalence Study. Circulation 61: 302-315, 1980.

60. Sedgwick, Anthony W. et al. Long Term Effects of Physical Training Programmes on Risk Factors for Coronary Heart Disease in Otherwise Sedentary Men. Br. Med. J. 218: 7-10, 5 July 1980.

61. Froelicher, V.F. Does Exercise Conditioning Delay Progression of Myocardial Ischemia in Coronary Atherosclerotic Heart Disease? Cardiovasc. Clin. 8: 11-31, 1977.

62. Nora. James et al. Genetic-Epidemiologic Study of Early- Onset Ischemic Heart Disease. Circulation 61: 3, 503-508, March 1980.

63. Lambert, Craig A. Risk Factors and Life Style: A Statewide Health-Interview Survey. NEJM 306: 17, 1048)1951, 29 April 1982.

64. Myles, W.S. and C.L. Allen. Current Levels of Fitness in the Canadian Forces, in Proceedings of the First RSG4 Physical Fitness Symposium, NATO Report DS/DR (78)98, 1978.

65. Wolthius, Roger A. et al. The Response of Healthy Men to Treadmill Exercise. Circulation 55: 153-157, Jan 1977.

66. Forrester, James S. and Geo. A. Diamond. Electrocardiographic Stress Testing. The Debate Goes On (Probably). Adv. Cardiol. 27: 83-92, 1980.

67. Hickman, James R. Treadmill Testing for the Detection of Asymptomatic Coronary Disease in the Healthy Male, NATO/AGARD Report No. 681, p 6-1 - 6-9, March 1980.

68. Sohi, H.S. et al. Plasma High Lipoproteins and Coronary Artery Disease. Adv. Myocardiol. 2: 513-525, 1980.

69. Nitter-Hauge, S., et al. Angiographic and Risk Factor Characteristics of Subjects with Early Onset Ischaemic Heart Disease. Br. Heart J. 46: 325-330, 1981.

70. Gordon, T. et al. Coronary Heart Disease, Atherothrombotic Brain Infarction, Intermittent Claudication - A Multivariate Analysis of Some Factors Related to their Incidence. Framingham Study, 16 year follow up. Section 27, U.S. Government Print. Office, 1971.

71. Bardsley, J.E. A Treatise on the Relationship between Physical Fitness and Health Status as they Apply to the Occupational Setting, with Particular Emphasis on Aerobic Fitness, Coronary Heart Disease and the Canadian Military, M.Sc. Thesis, UBC, May 1982.

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CHAPTER 5

BODY COMPOSITION: MEASUREMENT AND ITS RELATION TO HEALTH AND PHYSICAL PERFORMANCE OF MILITARY PERSONNEL

5.1 INTRODUCTION

257. Body weight and body composition are related to health as well as to physical fitness and are usually expressed in absolute or relative amounts of body fat and lean body mass, the non-fat portion of the body.

258. Body weight and body fat are associated with increased risk of morbidity and mortality and are largely due to disturbances in carbohydrate and lipid metabolism and become manifest as cardiovascular disease. Besides the quantity of adipose tissue, the distribution of fat over the body has been shown to be an important factor in this relationship. Excess body fat contributes to decreased performance in relatively prolonged weight-bearing work by increasing the body weight, and consequently, the energy required to perform at any given level of work without contributing to the body's energy producing capacity (1). Physical training and physical fitness are important determinants of military physical performance (discussed in RSG-4). However, body composition has to be considered in the total context of factors which influence the serviceman's performance of physically demanding aspects of his job.

259. It is important to realize that body weight and body composition are influenced by natural factors such as sex, age, stature, race, and by nutrition and physical exercise as environmental factors (2). In addition it is suggested that human fatness is under substantial genetic control (3, 4).

260. In adults, changes in body weight are primarily caused by addition or loss of adipose tissue, due to imbalance between energy intake and energy output. Positive deviation from arbitrary standards is called overweight or obesity. In order to determine whether a serviceman is overweight or obese, techniques for quantifying body fat are required as well as standards. Moreover, if any comparison of cross-sectional and/or longitudinal results obtained with different NATO populations is to be attempted, standard methodology will be essential.

261. In this chapter the available methods for the determination of body composition will be discussed, as well as health and performance implications of overweight and obesity.

5.2 DETERMINATION OF BODY COMPOSITION

262. Both direct and indirect methods have been used to evaluate human body composition (5) (Table 5.1).

Table 5.1 Techniques for Determining Body Composition (5)

1. Direct carcass analysis
2. Indirect analysis of composition
   - Morphology or body build (somatotypes)
   - Anthropometric measurements
     - height and weight
     - circumferences and diameters
     - skinfold thicknesses
   - Body density and body volume
   - Isotope or chemical dilution
     - total body water
     - total body potassium
     - neutron activation
     - fat-soluble gases
   - Imaging techniques
     - soft tissue roentgenograms
     - ultrasound
     - computed tomography (CT)
     - nuclear magnetic resonance (NMR)
     - dual photon absoptiometry (DPA)
   - Electrical methods
     - total body electrical conductivity (TOBEC)
     - tetrapolar bioelectric impedance (TBI)
   - Infrared interactance (IRI)

5.2.1 Direct Analysis of Body Composition

263. There are two different, though overlapping, approaches to the determination of body composition - a chemical and an anatomical method. Data on body composition come from cadaver studies, although until recently only 8 complete adult dissections carried out for body composition purposes have been reported in the literature since 1940. 'The Brussels Cadaver Analysis Study' has extended this number with 25 dissections (6).

264. The paucity of direct data and the impossibility of in-vivo dissection have led to a proliferation of indirect methods, in which some readily measurable body parameter is used to estimate the amount of one or more body constituents. Commonly used parameters are whole body density, body potassium, body water and various anthropometric measurements, especially skinfold thicknesses. The basis for most body composition studies is formed by the reduction of the human body to two compartments: fat and fat-free tissue. This 2-component model requires the assumption of a constant fat-free weight composition. However, 'The Brussels Cadaver Analysis Study' has thrown considerable doubt on this assumption (6).

5.2.2 Indirect Analysis of Body Composition

5.2.2.1 Morphology (Body Build)

265. Superficial analysis of fatness may be done by self-examination or through visual examination by another person. Although such observations provide a good individual guide they are not quantitative (5). Appearances in uniform and bathing suit have been used in a body composition study conducted by the United States Army Research Institute of Environmental Medicine (7). A quantitative method of describing human morphology is that of somatotyping in which size dissociated shape is expressed by a 3 number rating that represents the components of endomorphy (fatness), mesomorphy (muscularity) and ectomorphy (leanness). The original Sheldon-technique was photoscopic, but the currently most frequently used adaptation is the anthropometric method of Heath and Carter (8). Because anthropometric measures help to constitute body morphology, it seems reasonable to hypothesize that prior categorization of subjects according to somatotype would increase the accuracy of anthropometric body composition methods (9).

5.2.2.2 Anthropometric Measurements

266. Anthropometric measurements involve determination of height, weight, various body circumferences or diameters, and the measurement of skinfold thicknesses.

5.2.2.2.1 Weight-Height Indices

267. The most widely used indices of relative weight are based on body weight in relation to height. In the choice of an accurate index of relative weight derived from measures of body weight and height, two criteria have been considered: firstly, the index should be relatively independent of height and, secondly the correlation between the index and body fat should be as high as possible (10).

268. The tables of 'ideal weight' provided by the Metropolitan Life Insurance Company (1959) are most widely used. It is imaginable that correction of body weight for frame size could provide a better indication of body fatness, because it is assumed that frame measures provide an estimate of fat free mass. However, the inclusion of frame-size categories was subject of criticism because no objective definition of frame size was available to determine these categories. In the new Metropolitan Life Insurance Company (1983) height and weight tables, elbow diameter was introduced as a measure of frame size. Recent research, however, showed that it is not likely that weight-height tables will be improved by the inclusion of frame size categories (11,12). Others suggest the use of body diameters other than elbow diameter (13).

269. Weight and height can also be related by various ratios, such as W/H, W/H^2 (Quetelet Index or Body Mass Index), $W/H^{1/3}$ (Ponderal Index) and W/H^p (Benn's populations specific index) (14). In Benn's index p is derived from the observed weight-height data in the population studied (15). The Benn's index fulfills the first demand of an accurate weight-height index because of its uniform independence of height, and it is suggested that it will prevent misleading results (16). Whatever the theoretical advantage of a totally height-unrelated index, in practice W/H^2 is easier to establish. Moreover, Benn's index conveyed no material advantage over W/H^2 because it is closely correlated to other weight-height indices, and no more so to other measures of fatness (12,17). With respect to the correlation of weight-height ratios and fatness, the reported correlation coefficients of W/H^2 ranges from 0.61 to 0.91 (10,18, 19,20). Other weight-height indices correlated less. The available evidence suggests that on linear correlation the W/H^2 index explains about half of the variation in percentage of fatness in population groups. However, it is questionable whether linear correlation is the appropriate mathematical analysis, as this relationship appears to be curvelinear (14). It has been shown that W/H^2 is more a measure of body fat mass than of percentage of body fat (21,22), as the relation between W/H^2 and fat weight divided by height squared (F/H^2) appeared to be linear and W/H^2 explained more than 90% of the variance in body fat mass.

5.2.2.2.2 Circumferences and Diameters

270. Circumferences and diameters have been used by physical anthropologists to quantify body build (8,23). Diameters represent frame size and fat-free mass (24), circumferences represent fat-free and fat-mass. In recent years the waist-hip circumference ratio has been used to describe fat distribution over the body, distinguishing android ('apple-shape') and gynoid ('pear-shape') fat distribution (25). Recently circumferences have been used to predict body composition in U.S. females (26) and Navy personnel (27,28,29). The reliability of body circumferences is comparable with that of skinfold thicknesses (30).

5.2.2.2.3 Skinfold Thicknesses

271. Since a large proportion of fat is deposited in the subcutaneous layer, the caliper measurement of the thickness of skinfolds picked up at various sites yields an estimate of total body fat (31).

272. As with most techniques, there are technical and biological limitations associated with the caliper method which may result in inaccurate measurement of subcutaneous fat thickness. These limitations include the inter- and intra-subject variation of skinfold compressibility, the inability to palpate the fat-muscle interface and the impossibility of obtaining interpretable measurements on very obese subjects (32,33,34). Additionally, inter-observer variability as well as the use of different types of skinfold calipers may contribute to measuring errors (35,36,37, 38).

273. In predicting body composition, regression models use various combinations of skinfolds as independent variables and hydrostatically measured body density as 'golden' standard. As with measuring skinfold thicknesses, the prediction equations require better standardization and refinement of techniques to improve their validity. For example, in several studies there was a reduced accuracy as a result of equations being derived from one sample of subjects to predict the body composition of a sample of subjects other than the one from which the equations were derived (39,40,41,42). These are population-specific equations because of methodological and biological factors. Methodological factors include the technical limitations of skinfold measurements already mentioned, as well as statistical limitations such as the use of small sample sizes with many independent variables, failure to cross-validate formulated equations on other population groups, and inappropriate methods of expressing data, for example, using linear equations for curve-linear relationships. The non-linear relation between skinfold fat and body density affects the slope of the regression line, while aging affects the intercept (43). The biological factors responsible for the variation of predicting density from skinfolds may include the assumption of a constant density of fat-free mass, the proportion of fat situated subcutaneously, the patterns of subcutaneous fat distribution over the body, and the already mentioned skinfold compressibility (44). Most of the mentioned factors are influenced by age, sex, race and/or ethnicity, and degree of adiposity. Generalized equations, are the results of a more recent attempt which is based on large, heterogeneous samples varying greatly in age and degree of body fatness. These newer equations take into account the potential change in ratio of internal to external fat and bone density with age, and the non-linear relationship between skinfold fat and body density (45). Durnin and Womersley (46) were the first to consider the development of equations that could be used over a more varied population, and they were followed by others (47,48,49). With respect to the correlation of skinfold measurement predictions and body density measurements, the reported multiple correlation coefficients range from 0.82 to 0.92, which suggests that skinfold thickness measurements explain almost 75 percent of the variance in body density. However, recently the poor performance of these generalized equations attributed to biological factors precluding the development of generalized equations has been shown (44,50). Therefore, it is suggested to utilize anthropometric measurements directly rather than to translate them to predict body composition (51,52).

274. Despite all the disadvantages mentioned, skinfold thickness measurement provides a convenient and simple means of body composition assessment. The Durnin-method has actually been adopted by numerous investigators. Although most NATO nations are now using it, a lack of standardization, particularly in the choice of the suprailiac skinfold site, is evident. Two suprailiac sites are generally applied: 1) the site recommended by Weiner and Lourie (53): 1 cm above and 2 cm medial to the anterior superior iliac spine; 2) the modification of Durnin and Womersley (46): just above the iliac crest in the mid-axillary line. Site 2 is used by a number of NATO nations, and is the standard method in the Netherlands. The U.S. Army Weight Control Programme also applies this site. The U.K. Army use both sites, whereas the R.A.F. and the R.N. tend to measure site

1. Recent research has shown that the two different suprailiac sites result in a systematic difference in skinfold thickness (54,55). In addition, the subscapular skinfold measured at an angle of about 45' to the vertical in the Durnin-method is also at variance with the standard techniques described by Weiner and Lourie (53).

275. Recently a study on about 9000 individuals was undertaken in the UK, distributed over various population groups, differing in age (16-64 years), sex, socio-economic status, occupation and regional origin (56). About two thirds of the group were men and women in the three Armed Services (57). The results concerning the Armed Forces are presented in Tables 5.2 and 5.3. In Tables 5.4 to 5.15 other UK, US, Dutch and Canadian body composition studies are condensed 54,58,59,60,61,62,63,64,65, 66,67). In all these studies the Durnin-method (46) was used.

Table 5.2 Description of Male UK Armed Service Personnel (n=5072) (57)

Age Group (yrs)	n	Mean Weight (kg)	SD	Mean % Fat	SD	Mean Height (cm)	SD	Mean FFM (kg)	SD
16	370	65.5	7.8	13.4	3.2	174.8	6.6	56.5	5.8
17-19	1036	68.0	9.0	15.4	4.1	175.5	6.7	57.6	6.1
20-24	1204	72.4	9.8	16.6	4.7	176.0	6.6	60.4	6.3
25-29	760	75.1	11.3	17.4	4.6	176.2	7.1	62.0	7.2
30-34	692	76.5	10.8	21.1	3.8	175.6	6.4	60.4	6.5
35-39	550	76.9	10.6	21.1	3.7	175.6	6.6	60.7	6.7
40-44	262	78.2	11.0	24.5	4.6	175.4	6.6	59.0	6.4
45-49	142	80.3	10.1	25.5	4.3	176.5	6.3	59.6	6.0
50-56	66	80.0	12.7	27.2	5.3	175.3	7.2	57.7	6.6

Table 5.3 Description of Female UK Armed Service Personnel (n=1007)

Age Group (yrs)	n	Mean Weight (kg)	SD	Mean % Fat	SD	Mean Height (cm)	SD	Mean FFM (kg)	SD
17-19	399	60.5	8.0	28.0	3.9	163.2	6.1	43.3	4.5
20-24	469	61.4	8.7	28.1	4.5	164.1	6.8	43.9	4.7
25-29	104	60.7	9.3	27.2	5.0	163.9	6.9	43.8	5.0
30-34	35	58.9	7.7	29.8	3.6	160.1	5.3	41.1	4.0

Table 5.4 Physical Characteristics of Males Participating in the UK Fitness Survey (n=2275) (54)

	Mean	SD
Age (years)	24.3	4.9
Weight (kg)	71.2	10.5
Height (cm)	173.2	6.5
Sum skinfolds (mm)	45.1	19.8
Body fat (%)	18.0	5.3

Table 5.5 Physical Characteristics of Dutch Male (n=1184) and Female (n=119) Candidates Tested at the Entry Testing Station in 1983 (58)

	Male			Female		
	Mean	SD	Range	Mean	SD	Range
Age (years)	20.3	2.1	16.0- 28.0	19.2	1.9	16.0- 27.0
Weight (kg)	73.2	8.5	51.0-110.0	62.3	8.4	44.0- 81.0
Height (cm)	181.4	6.1	161.0-198.5	168.4	6.4	154.2-185.4
Skinfolds (mm)						
-bicipital	4.7	1.8	2.0- 17.5	7.9	2.7	3.0- 16.5
-tricipital	8.7	3.4	3.0- 26.0	14.3	4.2	7.0- 26.0
-subscapular	10.0	3.4	5.0- 36.5	12.3	4.0	5.5- 24.0
-suprailiac	15.5	8.2	4.0- 46.5	18.0	7.9	5.0- 38.0
Sum skinfolds (mm)	39.0	15.5	17.0-121.0	52.3	16.8	21.5- 91.0
Body fat (%)	15.2	4.3	6.2- 30.0	26.5	4.5	15.0- 34.8
FFM (kg)	61.9	5.7	47.2- 86.0	45.7	5.1	33.8- 59.0

Table 5.6 Physical Characteristics of US Males (n=595) and Females (n=217) Matched for Age with Dutch Data (58, 59)

US Personnel	Male Mean	Male SD	Male Range	Female Mean	Female SD	Female Range
Age (years)	22.9	3.0	18 - 28	22.2	2.5	18 - 27
Weight (kg)	74.2	10.4	50.9-126.9	59.6	8.0	43.6- 88.5
Height (cm)	174.3	6.6	155.6-193.2	162.3	6.3	144.0-179.2
Skinfolds (mm)						
-bicipital	5.2	2.1	2.4- 20.6	7.3	3.3	2.9- 25.6
-tricipital	10.6	4.3	3.9- 31.1	16.4	6.0	4.3- 39.7
-subscapular	14.2	5.4	4.0- 39.7	13.1	4.9	5.6- 29.8
-suprailiac	20.0	9.7	4.0- 40.7	16.6	8.8	3.4- 40.4
Sum skinfolds (mm)	49.9	19.0	17.9-112.3	53.4	19.5	20.7-118.0
Body fat (%)	17.0	4.9	4.0- 28.0	25.4	5.4	14.0- 38.0
FFM (kg)	61.3	6.9	44.6- 92.6	44.2	4.7	33.8- 60.2

Table 5.7 Physical Characteristics of Dutch Males (n=-595) and Females (n=217) Matched for Age with US Data (58, 59)

Dutch Personnel	Male Mean	Male SD	Male Range	Female Mean	Female SD	Female Range
Age (years)	22.5	2.9	18 - 28	21.9	2.4	18 - 27
Weight (kg)	75.0	10.7	53.1-126.9	59.9	8.1	45.2- 88.5
Height (cm)	175.3	6.6	155.6-193.2	162.9	6.2	147.9-179.2
Skinfolds (mm)						
-bicipital	5.4	2.3	2.4- 20.6	8.1	3.5	3.1- 25.6
-tricipital	11.0	4.0	4.0- 31.1	17.4	6.0	7.2- 39.7
-subscapular	14.1	5.2	6.7- 39.7	13.1	5.2	5.9- 29.8
-suprailiac	21.4	9.4	4.2- 40.7	17.5	8.9	3.4- 40.0
Sum skinfolds (mm)	51.9	18.2	21.3-108.3	56.1	20.2	20.7-118.0
Body fat (%)	17.6	4.6	8.0- 28.0	26.2	5.3	14.0- 38.0
FFM (kg)	61.5	6.8	45.7- 92.6	44.0	4.6	35.0- 60.2

Table 5.8 Physical Characteristics of Male Dutch Royal Air Force Personnel (69)

Age Group (yrs)	n	Mean Weight (kg)	SD	Mean % Fat	SD	Mean Height (cm)	SD
20-24	46	73.4	8.3	15.3	3.9	181.7	6.0
25-29	45	75.7	9.0	17.0	5.3	179.6	5.6
30-34	45	78.2	10.2	20.8	4.8	178.0	5.6
35-39	47	79.4	8.3	21.4	3.5	178.7	5.3
40-44	46	76.1	9.2	23.0	6.0	176.6	5.5
45-49	43	78.2	10.3	24.5	5.5	175.3	7.3
50-55	46	78.2	9.0	25.7	6.2	176.5	6.5

Table 5.9 Physical Characteristics of Male Dutch Junior Non-Commissioned Officers Aged 17 to 19 Years (n=57) (6)

	Mean	SD
Weight (kg)	69.0	8.0
Height (cm)	180.0	6.5
Body fat (%)	14.6	4.4
FFM (kg)	58.8	6.1

Table 5.10 Physical Characteristics of Male Dutch Army Personnel (n=428) (62)

	Mean	SD	Range
Age (years)	32	9	17- 49
Weight (kg)	75	9	49-103
Sum skinfolds (mm)	55	23	12-125
Body fat (%)	21	6	8- 36
FFM (kg)	59	6	39- 76

Table 5.11 Physical Characteristics of Male Dutch Non-Commissioned Officers (n=136) (63)

	Mean	SD	Range
Age (years)	35.6	5.0	29.7- 51.4
Weight (kg)	80.1	9.8	62.1-116.7
Height (cm)	178.4	6.9	160.3-194.7
Sum skinfolds (mm)	57.8	21.4	22.5-146.5
Body fat (%)	22.9	4.8	10.6- 37.6
FFM (kg)	61.5	6.0	49.1- 77.9

Table 5.12 Physical Characteristics of Male (n=90) and Female (n=10 Dutch Army Nutrition Officers (64)

	Male			Female		
	Mean	SD	Range	Mean	SD	Range
Age (years)	38.5	11.9	21.0- 61.0	28.5	5.6	23.0 - 42.0
Weight (kg)	79.5	8.3	60.0- 98.6	67.3	12.6	54.2 - 91.4
Height (cm)	178.3	6.3	160.8-190.6	170.8	7.9	157.7 -182.5
Sum of 4 skinfolds (mm)	57.3	18.2	19.2-100.6	62.3	17.0	29.9 - 79.3
Body fat (%)	23.9	6.5	7.5- 37.4	26.7	6.7	12.9 - 35.8
Waist/hip ratio	0.86	0.06	0.7- 1.04	0.70	0.04	0.62 - 0.77

Table 5.13 Physical Characteristics of Male Dutch Army Officers (n=64) (65)

	Mean	SD	Range
Age (years)	32.1	2.8	29 - 42
Weight (kg)	80.2	9.6	63.2 - 105.0
Height (cm)	181.5	6.2	168.9 - 196.0
Sum of 4 skinfolds (mm)	57.2	22.0	22.7 - 119.2
Body fat (%)	22.1	4.4	13.3 - 30.9
Waist/hip ratio	0.86	0.04	0.78- 0.93

Table 5.14 Physical Characteristics of Canadian Forces Male Personnel (Mean and SD in Brackets) (163)

Age Group yrs	n	Age yrs	Height cm	Weight kg	Density g/cc	Body Fat % *	Body Fat % **	FFM kg *
17 - 29	71	22 (3)	174 (6)	74 (9)	1.068 (0.014)	13.7 (6.1)	15.6 (4.1)	63.4 (6.1)
30 - 39	24	33 (2)	173 (5)	76 (5)	1.057 (0.017)	18.2 (7.7)	21.3 (3.9)	62.0 (7.4)
40 - 49	15	44 (3)	178 (7)	86 (14)	1.042 (0.014)	25.2 (6.3)	27.1 (5.5)	63.0 (7.9)
all ages	110	27 (9)	174 (6)	76 (11)	1.062 (0.017)	16.2 (7.7)	18.2 (6.0)	63.0 (8.8)

* determined from underwater weighing
** determined from skinfold measurements
(Body fat determined from skinfolds significantly different from body fat determined by UWW, $p<0.05$)

Table 5.15 Physical Characteristics of Canadian Female Personnel (Mean and SD in Brackets) (67)

Age Group yrs	n	Age yrs	Height cm	Weight kg	Density g/cc	Body Fat % *	Body Fat % **	FFM kg *
19 - 29	25	24 (3)	162 (5)	60 (7)	1.040 (0.010)	25.9 (4.4)	25.9 (4.0)	44.1 (4.1)
30 - 39	24	33 (2)	163 (6)	64 (12)	1.035 (0.018)	28.2 (8.2)	29.2 (6.1)	45.3 (6.2)
40 - 56	17	46 (4)	165 (5)	70 (11)	1.020 (0.010)	35.4 (4.6)	35.4 (4.6)	45.0 (6.2)
all ages	66	33 (9)	163 (5)	64 (11)	1.033 (0.016)	29.2 (7.2)	29.6 (6.3)	44.8 (5.5)

* determined from underwater weighing
** determined from skinfold measurements

276. The calculation of error of percent of body fat from density and from skinfold thicknesses has always led to juggling with figures. In predicting body density from skinfold measurements according to the Durnin-method, the standard error of the estimate (SEE) is approximately 0.0087 g/ml (3.8% fat) in males and 0.0102 g/ml (4.4% fat) in females (18, 46). Other equations provide comparable figures (49). The scatter about the regression line for body density with skinfolds is caused by the already mentioned biological differences in the proportion of subcutaneous fat in its compressibility and fat content, and its distribution over the body. Often the standard error of the estimate is presented as the total error in estimating percent of body fat (18,49). However, the error connected with estimating percent of body fat from density by one of the available equations (see 5.2.2.3) is not included. This error, associated with the variability in the density and composition of fat-free mass, must be added to the error connected with predicting body density in order to provide an accurate estimate of the total error in estimating 'true' percent fat (68). Applying the Law of Propagation of Errors (69), the total error resulting from converting skinfolds to 'true' body fatness (see 5.2.2.3) is approximately 5.3% fat in men and 5.8% fat in women.

5.2.2.3 Body Density and Body Volume

277. In the assessment of the total fat mass of the human body, measurement of body density is a well established technique used as a 'golden' standard for other body composition measuring-techniques, and was pioneered by Behnke et al. in 1942 (70). They demonstrated that football players who had been rejected for military service because of overweight, were excessively muscular and not obese.

278. Density of the human body is commonly measured by weighing the body in air and subsequently completely immersed in water or by water displacement. In both methods, the value obtained for body volume is corrected for the volume of air in the lungs at the moment of measurement. Usually no allowance is made for the volume of air in the gut, since this is assumed to be too small to be of significance, particularly in the fasting subject. Special attempts have been made to measure body volume without requiring the subject to be totally immersed in water (71,72,73).

279. Various equations have been evolved for the relation between fat content and body density depending on the estimated density of fat and fat-free tissue. One of the most widely used equations is that developed by Siri, assuming that the density of fat is 0.900 g/ml and the density of fat-free tissue is 1.100 g/ml (49). Other equations are provided by Brozek (74) and Behnke (75).

280. As already mentioned, these equations are based on the assumption that the density of the fat-free part of the body is constant. However, it is estimated that the standard deviation of lean body mass is 0.01 g/ml (69) or even 0.017 (14). Although body density can be measured with a precision of 0.0008 to 0.0023 g/ml (76,77), the value of 0.0025 g/ml is a more realistic appraisal in routine circumstances (69). As the influence

of the uncertainty about the density of the fat-mass can be fully ignored, the error sources mentioned result in an overall standard deviation of 3.8% fat (69). Based on completely arbitrary assumptions, the standard deviation for a specific population is estimated to be 2.7 % fat.

5.2.2.4 Isotope or Chemical Dilution

281. Fat-free body mass can be determined by measuring total body water, total body potassium and neutron activation, while fat soluble gases are used to measure body fat mass.

5.2.2.4.1 Total Body Water

282. Water is normally the largest component of body weight: for example a man weighing 70 kg will contain about 42 kg of water equal to 60% of body weight (78). The total amount of water in the body can be measured with an isotopic dilution or dilutions of other chemicals such as antipyrine, urea, or alcohol. Nowadays total body water is measured by assessing the dilution of the isotopic labels: tritium (^3H), or the stable isotopes of hydrogen and oxygen: deuterium (^2H) and ^{18}O. The water compartment is relatively easy to measure, since a tracer dose of water, labelled isotopically, will reach an equilibrium with virtually all body water in 3 to 4 hours (31). If the equilibrium concentration is measured, the volume of dilution (total body water) can be calculated. Although according to the theory that water represents a fixed fraction - approximately 73 % - of the nonfat part of the body, this does not always hold true, even in normally hydrated bodies (79).

5.2.2.4.2 Total Body Potassium

283. Since potassium is present mainly in the intracellular phase, the measurement of the potassium content of the body enables the estimation of the lean body mass. The total body potassium content is determined by two methods: 1) direct measurement of the gamma radiation emitted by the radioactive 40K, which occurs as a constant proportion in natural potassium; 2) measurement of the total exchangeable potassium by isotopic dilution using 42K as a tracer (79). Although the method has been refined with the aid of additional knowledge about potassium distribution, use of appropriate phantoms and calibration procedures, uncertainties remain. These uncertainties involve errors due to an incorrectly assumed distribution of 40K, an inappropriate constant used per kg body weight or fat-free body weight, differences in natural abundance, misapplied counting statistics, instability of counter performance, high background or instability of background, differences in body geometry, and variations in counting sensitivity (80).

5.2.2.4.3 Neutron Activation

284. In addition to the radioactive isotope of potassium that occurs naturally, isotopes of nitrogen and other elements can be made radioactive by neutron irradiation of the subject (81,82,83,84). Recently the technique has been validated by comparison with chemical analysis of human cadavers (85). The apparatus required is similar to that needed for 40K measurement, with the addition of a neutron activation facility. It is an expensive and not widely used technique.

5.2.2.4.4 Fat Soluble Gases

285. Many gases such as xenon, krypton and cyclopropane as well as most anaesthetic gases are more readily soluble in fat than in water. Theoretically, therefore, it should be possible to measure total body fat by following the absorption of these gases using the dilution principle. However, this technique is very inconvenient for the subject, since it takes too long to establish the equilibrium conditions (86). Attempts to predict the final equilibrium uptake from early measurements have been foiled because depot fat is irregularly perfused, and hence the uptake curve is not a smooth one (31). The technique is not commonly used.

5.2.2.5 Imaging Techniques

286. To obviate some of the limitations of the caliper technique, as discussed earlier, alternative noninvasive and mostly imaging techniques have been proposed.

5.2.2.5.1 Soft-tissue Roentgenograms

287. Soft-tissue roentgenograms provide more accurate estimates of subcutaneous fat than the caliper technique. However, its application is not quite current because it can only be used at a limited number of relatively safe sites involving undesirable radiation exposure of the subject (34,87).

5.2.2.5.2 Ultrasound

288. Ultrasonic scanners are capable of measuring fat at depths of 100 mm or more without tissue compression, and can therefore be effective in very obese persons. Application of ultrasound involves no radiation exposure, and is safe and painless. There appears to be strong correlation of ultrasonic measurement with direct measures of subcutaneous fat by soft-tissue roentgenograms (87) and surgical incision (88). In several studies the feasibility has been examined of using A-mode ultrasound to measure adipose tissue in humans (89,90,91,92). Compared with the caliper technique equal or less accuracy of the ultrasound technique was found. The ultrasound equipment available at present provides a two-dimensional

image of tissue configurations (B-mode). Recently, studies with B-mode ultrasound have been published (93,94). Until now ultrasound has not shown substantial improvement on skinfold calipers in normal weighed subjects. However, ultrasound has proven to be superior to the caliper technique in measuring subcutaneous fat in obese persons (95).

5.2.2.5.3 Computed Tomography

289. The applications of computed tomography (CT) to body-composition research are being explored rapidly, as CT is supposed to provide information which is unobtainable with any other technique. CT-scans are computer-reconstructed radiographic images which can be made of any body cross-section and depict fat and muscle with great clarity. Computer software available with modern CT scanners allows measurement of the total areas of fat or lean tissue in an image, measurement of linear distances between two points, and determination of density of selected tissues. In the abdomen, these features permit the differentiation of subcutaneous fat area from intra-abdominal area providing information about body fat distribution (96,97,98,99,100,101,102,103). Measurements of fat around and between muscles in the extremities can also be taken (104,105), as well as of the volume of fat tissue of the whole body (106,107). CT is an appropriate method of studying body fat volume and distribution as it can be done quickly and with only minimal hazard (radiation exposure less than 1 rad (100)).

5.2.2.5.4 Nuclear Magnetic Resonance (NMR)

290. Although it is a promising technique, the applications of nuclear magnetic resonance (NMR) in body-composition research are largely unexplored (108).

5.2.2.5.5 Dual Photon Absorptiometry (DPA)

291. It is possible by dual photon absorptiometry to obtain measurements of the lean percent of all body areas, and the fat free mass and the fat mass can be measured in vivo precisely and accurately (109, 110). However, the DPA method is too expensive and time consuming to be suitable for practical clinical determinations of body composition.

5.2.2.6 Electrical Methods

5.2.2.6.1 Total Body Electrical Conductivity

292. Total body electrical conductivity (TOBEC) is a method of estimating lean body mass electromagnetically. The TOBEC method is based on the principle of the electrical conductivity of lean tissue being far greater than that of fat, owing to the much higher electrolyte content of

lean tissue (111,112). This technique has been successfully applied to the determination of the fat content of live pigs (113). The EMME (Electronic Meat Measuring Equipment) has been adapted for use with human subjects, and has shown to be convenient, rapid, and safe, as well as to correlate well with more cumbersome human body composition techniques (114, 115,116,117,118). Relative to body density measurement, the TOBEC-method has a lower standard error of the estimate (SEE) than the Durnin-method: 3.3 vs. 4.5% fat (114). The TOBEC-equipment for human application is at present cost prohibitive and will probably not be portable.

5.2.2.6.2 Tetrapolar Bioelectrical Impedance (TBI)

293. Tetrapolar Bioelectrical Impedance (TBI), an estimate of fat-free mass, is based on the conduction of an applied electrical current in the organism. Application of a constant low level alternating current results in impedance to the spread of the current which is frequency dependent. Intra- and extracellular fluids behave as electrical conductors, and cell membranes as electrical condensers. High frequency current passes through both intra- and extracellular fluids. In this manner body fluids and electrolytes are responsible for electrical conduction and cell membranes are involved in capacitance (119). Although the technique is named impedance, in reality resistance is used, as it is assumed that the magnitude of reactance relative to resistance is small. Compared with body density measurement, the impedance method has a lower standard error of the estimate (SEE) than the Durnin-method: 2.7 vs. 3.9% fat (120). As impedance measurements take into account differences in fat distribution, it is suggested that the lower SEE may be attributed to this advantage (121). In recent studies this mentioned advantage could not be affirmed (114,122,123). In the last two years the validity of bioelectrical impedance measurements has been the subject of dispute (124,125,126,127). However, the method is safe, noninvasive, provides rapid measurements, requires little operator skill and subject cooperation and the apparatus is portable; it has great potential for use in surveys (128,129).

5.2.2.7 Infrared Interactance

294. Infrared interactance is based on the principles of light absorption, reflection, and near-infrared spectroscopy (130,131). It is an alternative to the skinfold caliper technique. The method is safe, noninvasive, rapid, and easy to use. However, more studies are needed to further evaluate it as a technique to measure body composition.

5.2.3 Accuracy of Techniques

295. The relationship of technique-related accuracy, subject burdening time necessary to complete determination and financial aspects are depicted in Figure 5.1.

Figure 5.1 Subject Burdening, Measuring Time and Cost of Various Techniques for Determining Body Composition vs Accuracy

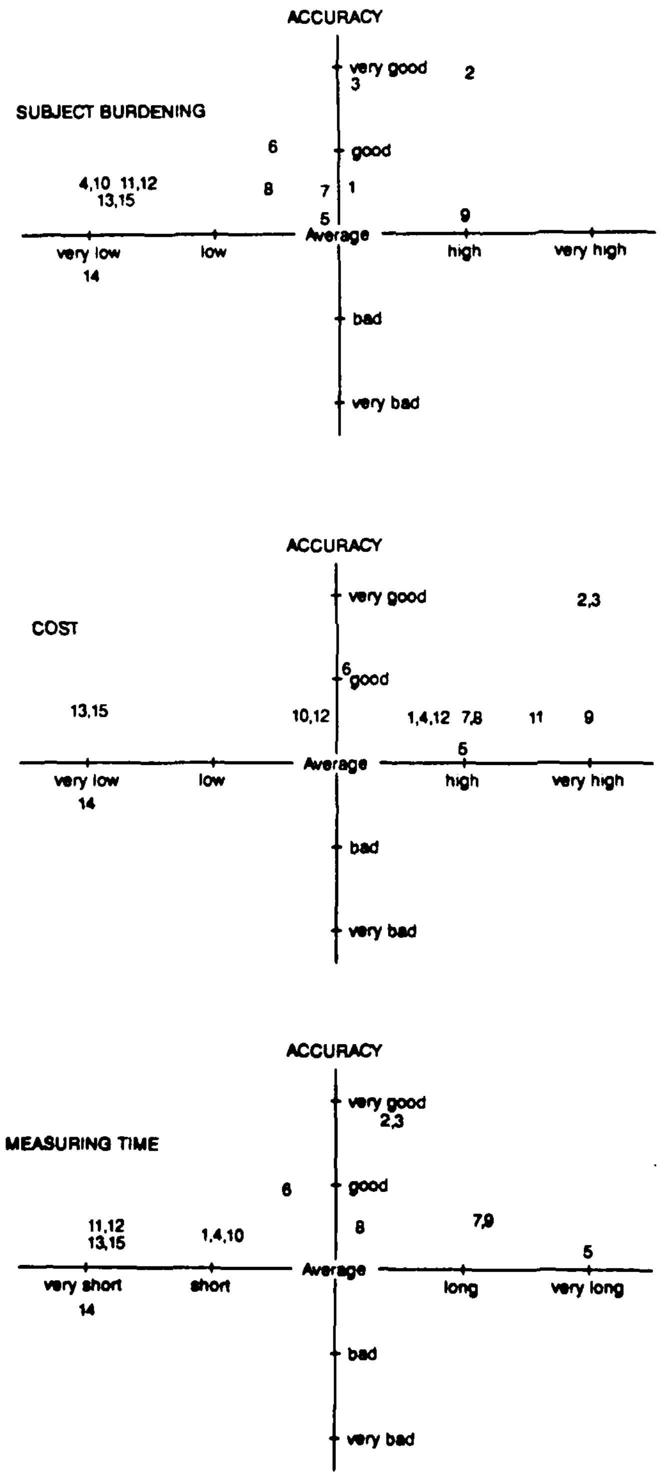

Figure 5.1

1 - soft tissue roentgenograms
2 - computed tomography (CT)
3 - nuclear magnetic resonance (NMR)
4 - ultrasound
5 - dual photon absorptiometry (DPA)
6 - body density
7 - total body potassium
8 - total body water
9 - neutron activation
10 - infrared interactance (IRI)
11 - total body electrical conductivity (TOBEC)
12 - tetrapolar bioelectric impedance (TBI)
13 - skinfold thicknesses
14 - Quetelet or body mass index (QI,BMI)
15 - circumferences

5.3. BODY COMPOSITION REFERENCE LIMITS

296. Few NATO-countries approach body composition by mandated weight control and official maximum allowable body fat standards. The U.S.A. Army Weight Control Program (132,133) and the Canadian Forces (134) define overweight/obesity by means of cut-off points or reference limits (Tables 5.16 and 5.17). In the first instance overweight is identified if individuals exceed screening table weight (Tables 5.18 and 5.19) (133, 135). The Army Weight Control Program uses the skinfold technique of Durnin and Womersley (132) or circumferences (133). The Canadian Forces determine obesity by means of the body mass index (BMI) (134). Denmark has height/weight-tables indicating ranges of 'normal weight' (136).

Table 5.16 US Army Body Fat Standards Expressed as a Percentage of Body Weight by Age and Sex (132, 133)

Sex	Age (years)			
	17 - 20	21 - 27	28 - 29	40+
	<------------------	%	------------------>	
men	20	22	24	26
women	28	30	32	34

Table 5.17 Canadian Forces Body Composition Standards Expressed as Body Mass Index (BMI) (135)

Sex	Age (years)				
	16 - 19	20 - 29	30 - 39	40 - 49	50 - 59
men	26	28	30	31	31
women	26	27	29	31	31

Table 5.18 Weight for Height Tables (Screening Table Height) (USA) (133)

Height (inches)	Male Age				Female Age			
	17-20	21-27	28-39	40+	17-20	21-27	28-39	40+
58	-	-	-	-	109	112	115	119
59	-	-	-	-	113	116	119	123
60	132	136	139	141	116	120	123	127
61	136	140	144	146	120	124	127	131
62	141	144	148	150	125	129	132	137
63	145	149	153	155	129	133	137	141
64	150	154	158	160	133	137	141	145
65	155	159	163	165	137	141	145	149
66	160	163	168	170	141	146	150	154
67	165	169	174	176	145	149	154	159
68	170	174	179	181	150	154	159	164
69	175	179	184	186	154	158	163	168
70	180	185	189	192	159	163	168	173
71	185	189	194	197	163	167	172	177
72	190	195	200	203	167	172	177	183
73	195	200	205	208	172	177	182	188
74	201	206	211	214	178	183	189	194
75	206	212	217	220	183	188	194	200
76	212	217	223	226	189	194	200	206
77	218	223	229	232	193	199	205	211
78	223	229	235	238	198	204	210	216
79	229	235	241	244	203	209	215	222
80	234	240	247	250	208	214	220	227

Notes :

1. The height will be measured in stocking feet (without shoes), standing on a flat surface with the chin parallel to the floor. The body should be straight but not rigid, similar to the position of attention. The measurement will be rounded to the nearest inch with the following guidelines:

   a. If the height fraction is less than 1/2 inch, round down to the nearest whole number in inches.
   b. If the height is 1/2 inch or greater, round up to the next highest whole number in inches.

Notes (continued)

2. The weight should be measured and recorded to the nearest pound within the following guidelines.

   a. If the weight fraction is less than 1/2 pound, round down to the nearest pound.
   b. If the weight fraction is 1/2 pound or greater, round up to the next highest pound.

3. All measurements will be in a standard PT uniform (gym shorts and T-shirt, without shoes).

4. If the circumstances preclude weighing soldiers during the APFT, they should be weighed within 30 days of the APFT.

5. Add 6 pounds per inch for males over 80 inches and 5 pounds for females for each inch over 80 inches

   1 kg = 2.2046 pounds
   1 inch = 2.54 cm

Table 5.19 Height Weight Tables (Canada) (135)

	Male/Female		
Height (cm)	Desirable weight (kg)	Overweight (kg)	Obese (kg)
152	46.2 - 57.8	62.4	69.3
154	47.4 - 59.3	64.0	71.1
156	48.7 - 60.8	65.7	73.0
158	49.9 - 62.4	67.4	74.9
160	51.2 - 64.0	69.1	76.8
162	52.5 - 65.6	70.9	78.7
164	53.8 - 67.2	72.6	80.7
166	55.1 - 68.9	74.4	82.7
168	56.4 - 70.6	76.2	84.7
170	57.8 - 72.3	78.0	86.7
172	59.2 - 74.0	79.9	88.8
174	60.6 - 75.7	81.7	90.8
176	62.0 - 77.4	83.6	92.9
178	63.4 - 79.2	85.5	95.1
180	64.8 - 81.0	87.5	97.2
182	66.2 - 82.8	89.4	99.4
184	67.7 - 84.6	91.4	101.6
186	69.2 - 86.5	93.4	103.8
188	70.7 - 88.4	95.4	106.0
190	72.2 - 90.3	97.5	108.3
192	73.7 - 92.2	99.5	110.6
194	75.3 - 94.1	101.6	112.9

Notes:

1. Desirable weight calculated at BMI 20-25 kg/MJ, overweight greater than 27 kg/MJ and obesity greater 30 kg/MJ.

2. These are population derived statistics and individual variation can occur within these broad categories.

5.4 BODY COMPOSITION AND HEALTH

297. Body weight is determined by a complex interaction of genetic, cultural, behavioural and psychological factors, all of which may have separate effects on health and longevity. Although in various studies body weight is associated with disease, it is difficult to assign specific effects to weight alone.

298. The relationship between body weight or body fat and medical complications has shown to be curve-linear in many studies; as body weight increases, the relative risk of complications increases logarithmically and results in a U-shaped or J-shaped curve. The major diseases associated with obesity are hypertension, atherosclerosis and diabetes, as well as certain types of cancer. Less well-known complications include hepatic steatosis, gallbladder diseases, pulmonary function impairment, endocrine disorders, obstetric complications, trauma to the weight-bearing joints, gout, cutaneous disease, proteinuria, increased hemoglobin concentration, and possibly immunologic impairment (137). Until now most attention has been paid to the association between obesity and the increased risk of cardiovascular disease.

299. The risks of obesity have recently been discussed in a "Consensus development conference on the health implications of obesity", organized by the National Institutes of Health (NIH). The Consensus Conference Statement has been published (138), followed by several discussions (139, 140).

300. In most public health studies and clinical practice, simple and convenient anthropometric measurements based on height, weight and skinfold thickness are used. Two methods are widely applied: estimation of relative weight (measured body weight divided by the midpoint of desirable weight for a person of medium frame as recommended by the Metropolitan Life Insurance Tables), and body mass index (see 5.2.2.2.1). Because the amount of body fat as estimated by the above mentioned indices, is a continuous variable, all quantitative definitions of obesity must be arbitrary. It is stated that a body weight of 20% or more above desirable body weight constitutes an established health hazard (141). Body mass index values, which correspond to 20% above desirable weight, are 27.2 and 26.9 for men and women, respectively, according to the 1983 Metropolitan Life Insurance tables (138). Another way to express health hazards is to divide the curvelinear relationship between body mass index and health risks into four levels. Level I comprises persons of normal body weight with a body mass index of 20 to 25 kg/m. Level II is defined as a body mass index of 25 to 30 kg/m (overweight), a range associated with low risk. Level III comprises persons with a body mass index of 30 to 40 kg/m (obesity); a range associated with moderate risk. Level IV contains persons who are massively obese, with a body mass index above 40 kg/m, submitting them to a high risk (137). This classification is comparable to the Garrow-classification (142). No generally used cut-off values for the (Durnin) skinfold method are available, however, obesity in men might be defined as a body fat content greater than 25 percent of total body weight; for females a comparable definition would be a body fat content greater

than 30 percent of total body weight (143).

301. Apart from demonstrating that body weight is related to the risk of developing premature cardiovascular disease, univariate analysis has also shown to be associated with most of the known risk factors for atherosclerosis, such as hypertension, cigarette smoking, low levels of High Density Lipoprotein (HDL) cholesterol, elevated plasma glucose levels, hypercholesterolemia, and hypertriglyceridemia.

302. With respect to age, the relative risks of hypertension, hypercholesterolemia, and diabetes seem to be greater in overweight adults aged 20 to 45 years than in overweight persons aged 45 to 75 years. This observation is consonant with mortality data, suggesting that being overweight during early life is more dangerous than a similar degree of overweight in later adult life (141).

303. When multivariate analysis is used to consider all of these additional risk factors, the relationship between obesity and cardiovascular disease is markedly attenuated (144). This does not mean that obesity is not associated with an increased risk, although it seems to be mediated by the mentioned risk factors of cardiovascular disease which, with the exception of cigarette smoking, are not real confounders in epidemiological terms. Cigarette smoking, however, has shown to be a potential confounder of the relationship between obesity and the risk of cardiovascular disease (145,146); in many studies it has been observed that smokers are leaner than non-smokers.

304. In contrast to the consistent relationship of obesity to risk factors in developing cardiovascular disease in the majority of studies (for example, NHANES I and II) widely divergent results have been reported for the relation to the incidence of cardiovascular disease observed in cohort-studies (for example, Framingham Study, American Cancer Society Study, U.S. Pooling Project). The inconsistencies appear not to be explained by differences in the definition of obesity, duration of follow up, or risk factor distribution. Neither misclassification bias or chronic disease seems to explain the inconsistencies (147). In studies in which obesity predicted cardiovascular disease it was usually found that obesity was not a risk factor independent of the standard risk factors. However, the Framingham study, a large population based study that is strengthened by having a long duration follow-up, recently disclosed an increasing risk of coronary artery disease with increasing levels of obesity, independent of the other risk factors (148).

305. Two theories are supposed to explain the doubtful and inconsistent association between obesity and precipitation of ischaemic heart disease. Firstly, a primary factor both causes obesity and precipitates ischaemic heart disease as a secondary phenomenon, as suggested earlier. Secondly, the association with cardiovascular disease is only found in a subgroup of persons with obesity; this effect would then be diluted in the whole population and difficult to find except in large populations after a long period of observation. There is considerable evidence that this second theory is a probable explanation too (149). The

idea of subgroups of obesity - android and gynoid fat patterning (25) - has been confirmed, and the original ideas have been transferred to more detailed and specific examinations (150,151,152). Fat patterning generally refers to differences in the ratio of internal to external (subcutaneous) adipose stores. Obesity located in the abdominal areas (android obesity) is the subgroup of persons with obesity showing complications endangering health and life (149).

306. The simplest method is to calculate ratios of circumferences or of skinfold thicknesses. A trunk and an extremity variable should be included in a ratio intended as a descriptor of fat patterning. One example is to record the waist circumference and to divide it by the hip circumference, in order to compensate for variation in frame size: the waist/hip ratio (WHR). The WHR (101) as well as waist and hip circumference (102) correlate highly significantly with the amount of intra-abdominal fat. There is, however, no consensus regarding the method that should be used to define fat patterning (153). Some sophisticated statistical methods have been used to define relative fat pattern, based on multiple skinfold thicknesses. Multivariate indices have included the construction of pattern profiles and clusters, factor analyses and principal component analyses. The relative advantages and disadvantages of the ratio and multivariate approaches have been described recently (154).

307. Prospective studies of regional patterns of obesity have been executed. In both men and women, selected at random, the waist/hip ratio was a risk factor for ischaemic heart disease, stroke, and death, independent of total body fat mass (155,156). Even at a normal body mass index, men with an increased waist/hip ratio ran a greater risk of developing ischaemic heart disease (155). Subcutaneous fat patterning by principal component analysis performed on skinfold data (157) has shown comparable results (158). These findings showed that the association between obesity and cardiovascular disease is found only in the obese population characterized by abdominal obesity.

308. Finally, a relation has recently been observed between fat distribution and subjective health (159,160), as well as between self-reported illness and medical care and body mass index (161).

5.5 BODY COMPOSITION AND PHYSICAL PERFORMANCE

309. Probably, everyone knows from the limited sample of his perception examples of the inverse relationship between overweight and/or obesity and weight-bearing exercise. However, little research has been executed to support this hypothesis.

310. The moderately negative relationship observed between percentage of body fat and distance running performance (162) and power output (163), could be confirmed in studies with U.S. and Dutch army personnel (7,62,63, 164). In addition, a negative relationship was found in other physical performance tests (62,63,164). Recently, a negative relationship has been observed between body fat and tibial nerve conduction velocity (165).

311. Body fat may also reduce aerobic power, expressed relative to body weight, thereby lowering the oxidative energy that can be made available to move each kilogram of body weight (166,167). However, others did not find this detrimental effect with respect to fat-free mass (1, 168). Irrespective of the suggested detrimental effect of body fat -in mathematical terms- on aerobic fitness, an abundant fat mass may have a negative motivational influence on the amount of habitual physical activity and aerobic training participation (166). However, this last hypothetical relationship has been subject to disputation until now (169,170,171). Recently it was shown that physical inactivity and percentage of body fat have an independent, significant detrimental effect on distance running (63) and aerobic power (168).

312. On the other hand, decreased body weight as result of caloric restriction, may affect physical performance negatively. In the Minnesota Semistarvation Experiment absolute oxygen uptake per minute during treadmill walking decreased by 28.5%, but neither oxygen uptake per kilogram body weight nor mechanical efficiency showed significant changes. Absolute aerobic power (VO_2 max) decreased by 42.7%. This deterioration was observed after 10 to 16% loss of original body weight (172).

313. An inverse association has been observed between aerobic power and risk factors of coronary artery disease (173,174). As body fat and physical activity influence both physical performance parameters and risk factors of ischaemic heart disease it may be assumed that both are confounders in this relationship. The relationship of body fat and health risks has been discussed in Chapter 4 and the association with physical performance is reviewed in this chapter. Referring to physical activity, there is epidemiological evidence that vigorous leisure-time activity in particular is inversely related to cardiovascular risk, and may be responsible for a small extension of longevity (175,176,177,178,179,180). However, positive selection and measurement of activity present problems in examining the relationship of ischaemic heart disease and physical activity (177,181). In order to assess the relationship of physical activity to health, it will be necessary to evaluate the complete spectrum of activities, from the lowest to the highest levels with standardized and valid approaches (177).

314. Finally, mention should be made of a review on the validity, the reliability and the practicality of physical activity assessment by questionnaire (182) that has recently been published.

5.6 DISCUSSION AND CONCLUSIONS

315. Excess body fat contributes to decreased (military) functional performance and increased health risks. Moreover, recent evidence strongly suggests that regional distribution of body fat is an additionally important determinant for the occurrence of clinical correlates of obesity such as cardiovascular disease, stroke and diabetes.

316. Overweight is defined as an increase in body weight above arbitrary standards defined in relation to health. The distinction between overweight and obesity depends on the choice of reference limits and can be made only if the amount of body fat can be estimated. The methods for assessing body fat can be divided into direct and indirect methods (Table 5.1). They are of varying accuracy and it is difficult to pinpoint one of the indirect methods as the most valid one. In addition, subject burdening, measuring time and cost are taken into account to the choice of a specific method. These issues are summarized in Figure 5.1. Currently, there is no agreement on a NATO-standard to define and assess overweight and obesity.

317. As regards the objective of body composition control on large groups of military personnel, the use of an easily applied and general method has to be recommended. Therefore, methods that depend on skinfolds, circumferences, bioelectrical impedance (TBI), or weight-height indices are preferred to methods such as densitometry, computed tomography, nuclear magnetic resonance, total body electrical conductivity, ultrasound, and isotope or chemical dilution.

5.7 SUMMARY

318. Excess body fat contributes to decreased military physical performance, especially in weight-bearing exercise. It is also associated with increased health risks like hypertension, atherosclerosis and diabetes and with orthopaedic disorders. Recent evidence strongly suggests that regional distribution of body fat is an additionally important determinant for the occurrence of clinical correlates of obesity like cardiovascular disease, stroke and diabetes. Overweight is defined as an increase in body weight above arbitrary standards defined in relation to health and/or physical performance.

319. The distinction between overweight and obesity depends on the choice of reference limits and can be made only if the amount of body fat can be estimated. The methods for assessment of body fat can be divided into direct (carcass analysis) and indirect methods. The latter ones can be divided in a morphological methods using somatotypes, anthropometric measurements, body density and body volume (the so-called "Golden Standard"), isotope or chemical dilution, imaging techniques, electrical methods and infrared interactance. They are of varying accuracy and it is difficult to pinpoint one of the indirect methods as the most valid one. For the purpose of body composition control on large groups of military personnel, an easy applicable and generalizable method has to be recommended. For those reasons, methods that depend on skinfolds, circumferences, bioelectrical impedance (TBI) or weight-height indices are preferred. However, for this moment there is no agreement on a NATO-standard to define and assess overweight and obesity.

5.8 REFERENCES

1. E. Buskirk and H.L. Taylor. Maximal oxygen uptake and its relationship to body composition, with special reference to chronic physical activity and obesity. J. Appl. Physiol. 11 (1957) 72-78.

2. G.B. Forbes. Body composition as affected by physical activity and nutrition. Fed. Proc. 44 (1985) 343-347.

3. A.J. Stunkard, T.T. Foch and Z. Hrubec. A twin study of human obesity. J.A.M.A. 256 (1986) 51-54.

4. A.J. Stunkard et al. An adoption study of human obesity. N. Engl. J. Med. 314 (1986) 193-198.

5. G.A. Bray. Obesity: definition, diagnosis and disadvantages. Med. J. Aust. 142 (suppl.) S2-S8 (1985).

6. J.P. Clarys, A.D. Martin and D.T. Drinkwater. Gross tissue weights in the human body by cadaver dissection. Hum. Biol. 56 (1984) 459-473.

7. P.I. Fitzgerald. The Body Composition Study of the United States Army. Research Institute of Environmental Medicine Lecture third RSG-8 meeting, Munich, 1985.

8. B.H. Heath, J.E.L. Carter. A modified somatotype method. Am. J. Phys. Anthropol. 27 (1967) 57-74.

9. R. Bulbulian. The influence of somatotype on anthropometric prediction of body composition in young women. Med. Sci. Sports Exercise 16 (1984) 389-397.

10. A. Keys et al. Indices of relative weight and obesity. J. Chronic. Dis. 25 329-343 (1972).

11. M.A. Rookus et al. The impact of adjustment of a weight-height index (W/H2) for frame size on the prediction of body fatness. Br. J. Nutr. 54 (1985) 335-342.

12. J.A.H. Baecke, J. Burema and P. Deurenberg. Body fatness, relative weight and frame size in young adults. Br. J. Nutr. 48 (1982) 1-6.

13. J.H. Himes and C. Bouchard. Do the new Metropolitan Life Insurance weight-height tables correctly assess body frame and body fat relationships? Am. J. Public Health 75 (1985) 1076-1079.

14. J.S. Garrow. Indices of obesity Nutr. Abstr. Rev. 53 (1983) 697-708.

15. R.T. Benn. Some mathematical properties of weight-for-height indices used as measures of obesity. Br. J. Prev. Soc. Med. 25 (1971) 42-50.

16. J. Lee, N. Kolonel and M.W. Hines. The use of an appropriate weight-height derived index of obesity can produce misleading results. Int. J. Obes. 6 (1982) 233-239.

17. S.M. Garn and S.D. Pesick. Comparison of the Benn index and other body mass indices in nutritional assessment. Am. J. Clin. Nutr. 36 (1982) 573-575.

18. J. Womersley and J.V.G.A. Durnin. A comparison of the skinfold method with an extent of 'overweight' and various weight-height relationships in the assessment of obesity. Br. J. Nutr. 38 (1977) 271-284.

19. N.G. Norgan and A. Ferro-Luzzi. Weight-height indices as estimator of fatness in men. Hum. Nutr.: Clin. Nutr. 36C (1982) 363-372.

20. D.A. Revicki and R.G. Israel. Relationship between Body Mass Index and measures of adiposity. Am. J. Public Health 76 (1986) 992-994.

21. J.D. Webster, R. Hesp and J.S. Garrow. The composition of excess weight in obese women estimated by body density, total body water and total body potassium. Hum. Nutr.: Clin. Nutr. 38C (1984) 299-306.

22. J.S. Garrow and J. Webster. Quetelet's index (W/H2) as a measure of fatness. Int. J. Obes. 9 (1985) 147-153.

23. R.W. Parnell. Behaviour and physique. Edward Arnold Publishers LTD., London, 1958.

24. W. von Dobeln. Anthropometric determination of fat-free body weight. Acta Med. Scand. 165 (1959) 37-40.

25. J. Vaque. The degree of masculine differentiation of obesities. Am. J. Clin. Nutr. 4 (1956) 20-34.

26. R.W. Cot, J.H. Wilmore. A practical assessment of body composition in young women. J. Sports Med. 26 (1986) 427-430.

27. J.A. Hodgdon and E.J. Marcinik. A survey of body fat content of U.S. Navy male personnel. Report No. 83-4, Naval Health Research Center, San Diego.

28. J.A. Hodgdon and M.B. Beckett. Prediction of percent body fat for U.S. Navy men from body circumferences and height. Report No. 84-11, Naval Health Research Center, San Diego.

29. J.A. Hodgdon and M.B. Beckett. Prediction of percent body fat for U.S. Navy women from body circumferences and height. Report No. 84-29, Naval Health Research Center, San Diego.

30. W.H. Mueller, R.M. Malina. Relative reliability of circumferences and skinfolds as measures of body fat distribution. Am. J. Phys. Anthropol. 72 (1987) 437-439.

31. J.S. Garrow. New approaches to body composition. Am. J. Clin. Nutr. 35 (1982) 1152-1158.

32. J. Brozek and W. Kinzey. Age changes in skinfold compressibility. J. Gerontol. 15 (1960) 45-51.

33. M.T. Fanelli and R.J. Kuczmarski. Ultrasound as an approach to assessing body composition. Am. J. Clin. Nutr. 39 (1984) 703-709.

34. J.H. Himes, A.F. Roche and R.M. Siervogel. Compressibility of skinfolds and the measurement of subcutaneous fat. Am. J. Clin. Nutr. 32 (1979) 1734-1740.

35. L. Burkinshaw, P.R.M. Jones and D.W. Krupowicz. Observer error in skinfold thickness measurements. Hum. Biol. 45 (1973) 273-279.

36. J. Womersley and J.V.G.A. Durnin. An experimental study on variability of measurements of skinfold thickness on young adults. Hum. Biol. 45 (1973) 281-292.

37. T.J. Housh, W.G. Thorland and G.O. Johnson. An evaluation of intertester variability in anthropometry and body composition assessment. J. Sports Med. 23 (1983) 311-314.

38. T.G. Lohman et al. Methodological factors and the prediction of body fat in female athletes. Med. Sci. Sports Exercise 16 (1984) 92-96.

39. M.M. Flint et al. Validity of estimating body fat of females: effect of age and fitness. Hum. Biol. 49 (1977) 559-572.

40. W.G. Thorland et al. Validity of anthropometric equations for the estimation of body density in adolescent athletes. Med. Sci. Sports Exercise 16 (1984) 77-81.

41. J.L. Mayhew et al. Accuracy of anthropometric equations for estimating body composition in female athletes. J. Sports Med. 25 (1985) 120-126.

42. J. Scherf et al. Validity of skinfold thickness measurements of formerly obese subjects. Am. J. Clin. Nutr. 43 (1986) 128-135.

43. A.S. Jackson. Research design and analysis of data procedures for predicting body density. Med. Sci. Sports Exercise 16 (1984) 616-620.

44. N.G. Norgan and A. Ferro-Luzzi. The estimation of body density in men: are general equations general? Ann. Hum. Biol. 12 (1985) 1-15.

45. M.L. Pollock and A.S. Jackson. Research progress in validation of clinical methods of assessing body composition. Med. Sci. Sports Exercise 16 (1984) 606-613.

46. J.V.G.A. Durnin and J. Womersley. Body fat assessed from total body density and its estimation from skinfold thickness: measurements on 481 men and women aged from 16 to 72 years. Br. J. Nutr. 32 (1974) 77-97.

47. A.S. Jackson and M.L. Pollock. Generalized equations for predicting body density in men. Br. J. Nutr. 40 (1978) 497-504.

48. A. Weltman and V.L. Katch. A non population-specific method for predicting total body volume and percent fat. Hum. Biol. 50 (1978) 151-158.

49. T.G. Lohman. Skinfolds and body density and their relation to body fatness: a review. Hum. Biol. 53 (1981) 181-225.

50. W.E. Sinning et al. Validity of "generalized" equations for body composition analysis in male athletes. Med. Sci. Sports Exercise 17 (1985) 124-130.

51. F.E. Johnston. Relationships between body composition and anthropometry. Hum. Biol. 54 (1982) 221-245.

52. A.D. Martin et al. Prediction of body fat by skinfold caliper: assumptions ar[illegible] [illegible]daver evidence. Int. J. Obes. 9(suppl.1) (1985) 31-39.

53. J.S. W[illegible]er and J.A. Lourie. Human Biology - a guide to field methods -IBP Handbook nr. 9 Blackwell, Oxford, UK, 1969.

54. A.F. Amor and C.D. Murch. The use of skinfold thickness data collection on the APRE physical fitness and anthropometric surveys to estimate body fat. Army Personnel Research Establishment Memorandum No. 47/76, 1978.

55. R. Luyken et al. Standardization of skinfold measurements. Ned. Mil. Geneesk. Tijdschr. 37 (1984) 195-199.

56. J.V.G.A. Durnin. The prevalence of obesity in the UK. Bibl. Nutr. Dieta 37 (1986) 11-17.

57. J.V.G.A. Durnin, F.C. McKay and C. Webster. A new method of assessing fatness and desirable weight for use in the armed forces. Ministry of Defence Contract Report. London 1985.

58. F.M. Bertina and M.J. van Dijk. Body composition and fitness of Dutch military personnel. Nederl. Mil. Geneesk. Tijdschr. 37 (1984) 82-85.

59. P.I. Fitzgerald Personal communication, 1986.

60. K.F.A.M. Hulshof and R.J. Egger. Cardiovascular risk factors: results of a study among Royal Netherlands Air Force personnel. Nederl. Mil. Geneesk. Tijdschr. 37 (1984) 61-69.

61. R.J. Egger, E.J. van der Beek and K.F.A.M. Hulshof. Longitudinaal onderzoek naar de voedingstoestand en het fysieke prestatievermogen van vrijwillig dienende militairen (KMS-Weert), 1980-1981 A. Veranderingen in voedingstoestand, bloeddruk en fysiek prestatievermogen TNO-CIVO-rapport nr. V 83.031/230002, 1983.

62. M. Bloem, E.J. van der Beek and M. Wedel. Obesity and physical performance in regular army personnel Nederl. Mil. Geneesk. Tijdschr. 37 (1984) 201-209.

63. E.J. van der Beek, M.J. van Dijk and M. Wedel. Body composition, life style and physical performance of male Dutch army non-commissioned officers To be published.

64. E.J. van der Beek Unpublished results (1987).

65. E.J. van der Beek, M.J. van Dijk, M. Wedel. Body composition, life style and physical performance of male Dutch army officers To be published.

66. D.G. Bell, K.M. Cox. Measurement of the body composition of Canadian forces male personnel DCIEM No. 84-C-05 Department of National Defence, Canada, 1984.

67. D.G. Bell, K.M. Cox. Measurement of the body composition of Canadian forces female personnel DCIEM No. 84-C-17 Department of National Defence, Canada, 1984.

68. K.J. Cureton. A reaction to the manuscript of Jackson Med. Sci. Sports Exercise 16 (1984) 621-622.

69. H.K. Bakker and R.S. Struikenkamp. Biological variability and lean body mass estimates Hum. Biol. 49 (1977) 187-202.

70. A.R. Behnke, B.G. Feen and W.C. Welham. The specific gravity of healthy men: body weight and volume as an index of obesity. J.A.M.A. 118 (1942) 495-498.

71. J.S. Garrow et al. A new method for measuring the body density in obese subjects. Br. J. Nutr. 42 (1979) 173-183.

72. B.L. Gundlach, H.G.M. Nijkrake and J.G.A.J. Hautvast. A rapid and simplified plethysmometric method for measuring body volume. Hum. Biol. 52 (1980) 23-33.

73. B.L. Gundlach, G.J.W. Visscher. The plethysmometric measurement of total body volume. Hum. Biol. 58 (1986) 783-799.

74. J. Brozek, F. Grande, J.T. Anderson, A. Keys. Densitometric analysis of body composition: revision of some quantitative assumptions. Ann. N.Y. Acad. Sci. 110 (1963) 113-140.

75. A.R. Behnke, J.H. Wilmore. Evaluation and regulation of body build and composition. Prentice-Hall, Inc, Englewood Cliffs, New Jersey, 1974.

76. J.V.G.A. Durnin and A. Taylor. Replicability of measurements of density of the human body as determined by underwater weighing. J. Appl. Physiol. 15 (1960) 142-144.

77. J. Mendez, H.C. Lukaski. Variability of body density in ambulatory subjects measured at different days. Am. J. Clin. Nutr. 34 (1981) 78-81.

78. J.S. Garrow. Energy balance and obesity in man. Elsevier/North Holland, Amsterdam, 1974.

79. F. Grande and A. Keys. Body weight, body composition and calorie status. In: R.S. Goodhart, M.E. Shills Modern nutrition in health and disease. Lea & Febiger, Philadelphia, 1980.

80. E.R. Buskirk and J. Mendez. Sport science and body composition analysis: emphasis on cell and muscle mass. Med. Sci. Sports Exercise 16 (1984) 584-593.

81. D. Vartsky, K.J. Ellis and S.H. Cohn. In vivo measurement of body nitrogen by analysis of prompt gammas from neutron capture. J. Nucl. Med. 20 (1979) 1158-1165.

82. S.H. Cohn et al. Compartmental body composition of cancer patients by measurement of total body nitrogen, potassium, and water. Metabolism 30 (1981) 222-229.

83. H.C. Lukaski et al. A comparison of methods of assessment of body composition including neutron activation analysis of total body nitrogen. Metabolism 30 (1981) 777-782.

84. S.J. Streat, A.H. Beddoe and G.L. Hill. Measurement of body fat and hydration of the fat-free body in health and disease. Metabolism 34 (1985) 509-518.

85. G.S. Knight et al. Body composition of two human cadavers by neutron activation and chemical analysis. Am. J. Physiol. 250 (1986) E179-E185.

86. G.T. Lesser, S. Deutsch and J. Markofsky. Use of independent measurement of body fat to evaluate overweight and underweight. Metabolism 20 (1971) 792-804.

87. E.M. Haymes et al. Validity of the ultrasonic technique as a method of measuring subcutaneous adipose tissue. Ann. Hum. Biol. 3 (1976) 245-251.

88. P.J. Balta, M.W.M. Ward and A.M. Tomkins. Ultrasound for measurement of subcutaneous fat Lancet i: (1981) 504-505.

89. G.A. Borkan et al. Comparison of ultrasound and skinfold measurements in assessment of subcutaneous and total fatness. Am. J. Phys. Anthropol. 58 (1982) 307-313.

90. M.T. Fanelli and R.J. Kuczmarski. Ultrasound as an approach to assessing body composition. Am. J. Clin. Nutr. 39 (1984) 703-709.

91. F.I. Katch. Individual differences of ultrasound assessment of subcutaneous fat: effects of body position. Hum. Biol. 55 (1983) 789-795.

92. P.A. Volz and S.M. Ostrove. Evaluation of a portable ultrasonoscope in assessing the body composition of college-age women. Med. Sci. Sports Exercise 16 (1984) 97-102.

93. W. Swobodnik et al. Ultraschall-Untersuchungen bei Adipositas zur Kalkulation der Fettgewebemasse In: H. Ditschuneit, J.G. Wechsler Ergebnisse der Adipositasforschung, pp 79-89 Erlangen: Perimed Fachbuch-Verlagsgesellschaft, 1984.

94. T. Weits, E.J. van der Beek and M. Wedel. Comparison of ultrasound and skinfold caliper measurement of subcutaneous fat tissue. Int. J. Obes. 10 (1986) 161-168.

95. R.J. Kuczmarski, M.T. Fanelli, G.G. Koch. Ultrasonic assessment of body composition in obese adults: overcoming the limitations of the skinfold caliper. Am. J. Clin. Nutr. 45 (1987) 717-724.

96. G.A. Borkan et al. Assessment of abdominal fat content by computed tomography. Am. J. Clin. Nutr. 36 (1982) 172-177.

97. A.K. Dixon. Abdominal fat assessed by computed tomography: sex difference in distribution. Clin. Radiol. 34 (1983) 189-191.

98. G.A. Borkan et al. Age changes in body composition revealed by computed tomography. J. Gerontol. 38 (1983) 673-677.

99. G.A. Borkan et al. Relationships between computed tomography tissue areas, thicknesses and total body composition. Ann. Hum. Biol. 10 (1983) 537-546.

100. W.O. Grauer et al. Quantification of body fat distribution in the abdomen using computed tomography. Am. J. Clin. Nutr. 39 (1984) 631-637.

101. M. Ashwell, T.J. Cole and A.K. Dixon. Obesity: a new insight into the anthropometric classification of fat distribution shown by computed tomography. Br. Med. J. 290 (1985) 1692-1694.

102. T. Weits et al. Computed tomographic measurement of abdominal fat deposition in relation to anthropometry. Int. J. Obesity: accepted for publication.

103. J.C. Seidell, A. Oosterlee, M.A.O. Thijjsen, J. Burema, P. Deurenberg, J.G.A.J. Hautvast, J.H.J. Ruijs. Assessment of intra-abdominal and subcutaneous abdominal fat: relation between anthropometry and computed tomography. Am. J. Clin. Nutr. 45 (1987) 7-13.

104. S.B. Heymsfield et al. A radiographic method of quantifying protein-calorie undernutrition. Am. J. Clin. Nutr. 32 (1979) 693-702.

105. R.J. Maughan, J.S. Watson and J. Weir. The relative proportions of fat, muscle and bone in the normal human forearm as determined by computed tomography. Clin. Sci. 66 (1984) 683-689.

106. K. Tokunaga et al. A novel method for the determination of body fat by computed tomography. Int. J. Obes. 7 (1983) 437-445.

107. H. Kvist, L. Sjostrom and U. Tylen. Adipose tissue volume determinations in women by computed tomography: technical considerations. Int. J. Obes. 10 (1986) 53-67.

108. D.S. Lewis et al. Use of NMR for measurement of total body water and estimation of body fat. J. Appl. Physiol. 60 (1986) 836-840.

109. A. Gotfredsen, J. Jensen, J. Borg, C. Christiansen. Measurement of lean body mass and total body fat using dual photon absorptiometry. Metabolism 35 (1986) 88-93.

110. C. Hassager, A. Gotfredsen, J. Jensen, C. Christiansen. Prediction of body composition by age, height, weight, and skinfold thicknesses in normal adults. Metabolism 35 (1986) 1081-1084.

111. G.G. Harrison and T.B. van Itallie. Estimation of body composition: a new approach based on electromagnetic principles. Am. J. Clin. Nutr. 35 (1982) 1176-1179.

112. E. Presta et al. Measurement of total body electrical conductivity: a new method for estimation of body composition. Am. J. Clin. Nutr. 37 (1983) 735-739.

113. W. Domermuth et al. Prediction of lean body composition of live market weight swine by indirect methods. J. Anim. Sci. 43 (1976) 966-976

114. K.R. Segal et al. Estimation of human body composition by electrical impedance methods: a comparative study. J. Appl. Physiol. 58 (1985) 1565-1571.

115. W.J. Cochran et al. Total body electrical conductivity used to determine body composition in infants. Pediatr. Res. 20 (1986) 561-564.

116. J.J. Cunningham. New approaches to the non invasive assessment of body composition: bioelectrical impedance analysis and total body electrical conductivity. Nutr. Int. 3 (1987) 6-10.

117. M.D. van Loan, A.Z. Belko, P.L. Mayclin, T.T. Barbiery. Use of total-body electrical conductivity for monitoring body composition changes during weight reduction. Am. J. Clin. Nutr. 46 (1987) 5-8.

118. M.D. van Loan, K.R. Segal, E. Filippo Braco, P. Mayclin, T.B. Van Itallie. TOBEC methodology for body composition assessment: a cross-validation study. Am. J. Clin. Nutr. 46 (1987) 9-12.

119. H.C. Lukaski, P.E. Johnson and W.W. Bolonchuk. Assessment of fat-free mass using bioelectrical impedance measurements of the human body. Am. J. Clin. Nutr. 41 (1985) 810-817.

120. H.C. Lukaski et al. Validation of tetrapolar bioelectrical impedance method to assess human body composition. J. Appl. Physiol. 60 (1986) 1327-1332.

121. J.A. Pasco and I.H.E. Rutishauser. Body fat estimated from anthropometric and electrical impedance measurements. Hum. Nutr.: Clin. Nutr. 39C (1985) 365-369.

122. J.A. Hodgdon, P.I. Fitzgerald. Validity of impedance at various levels of fatness. Hum. Biol. 59 (1987) 281-298.

123. M. van Loan, P. Mayclin. Bioelectrical impedance analysis: is it a reliable estimator of lean body mass and total body water ? Hum. Biol. 59 (1987) 299-309.

124. S.H. Cohn. How valid are bioelectric impedance measurements in body composition studies ? Am. J. Clin. Nutr. 42 (1985) 889-890.

125. F.I. Katch et al. Validity of bioelectrical impedance to estimate body composition in cardiac and pulmonary patients. Am. J. Clin. Nutr. 43 (1986) 972-973.

126. N.W. Solomons. How valid are bioelectric impedance measurements in body composition studies ? Am. J. Clin. Nutr. 44 (1986) 306-307.

127. S.H. Cohn. Response to Solomons's rebuttal. Am. J. Clin. Nutr. 44 (1986) 307-308.

128. S. Guo, A.F. Roche, W.M. Cameron Chumlea, D.S. Miles, R.L. Pohlman. Body composition predictions from bioelectrical impedance. Hum. Biol. 59 (1987) 221-233.

129. R.M. Malina. Bioelectric methods for estimating body composition: an overview and discussion. Hum. Biol. 59 (1987) 329-335.

130. J.M. Conway, K.H. Norris and C.E. Bodwell. A new approach for the estimation of body composition: infrared interactance. Am. J. Clin. Nutr. 40 (1984) 1123-1130.

131. J.M. Conway, S.D. Bulman, J.S. Collins, K.H. Norris, C.E. Bodwell. A comparison of new methods for estimating body composition: whole body impedance and near-infrared interactance. Am. J. Clin. Nutr. 41 (1985) 839.

132. W.J. Rinke, J.K. Herzberger, F.J. Erdtmann. The Army Weight Control Program: a comprehensive mandated approach to weight control. J.A.D.A. 85 (1985) 1429-1434.

133. Headquarters, Department of the Army: the Army Weight Control Program. Army Regulation 600-9, 1986.

134. Canadian Forces Surgeon General Medial Directive 5/86, Directorate of Medical Treatment Services, 26 June 1986.

135. Canadian Forces Administrative Order 19-34, Change 26/85.

136. Col. (Vet) T. Gregersen, Denmark. Personal communication, 1987.

137. G.A. Bray. Complications of obesity Ann. Intern. Med. 103 (1985) 1052-1062.

138. National Institutes of health consensus development panel on the health implications of obesity National Institutes of Health Consensus Development Conference Statement Ann. Intern. Med. 103 (1985) 1073-1077.

139. B.T. Burton, W.R. Foster, J. Hirsch, T.B. van Itallie. Health implications of obesity: an NIH consensus development conference. Int. J. Obes. 9 (1985) 155-169.

140. J. Hirsch. NIH consensus conferences: by whom, for what? -obesity. J. Nutr. 116 (1986) 1854-1856.

141. T.B. van Itallie. Health implications of overweight and obesity in the United States. Ann. Intern. Med. 103 (1985) 983-988.

142. J.S. Garrow. Treat obesity seriously - a clinical manual. Churchill Livingstone, Edinburgh, 1981.

143. G.A. Bray. Definition, measurement, and classification of the syndromes of obesity. Int. J. Obes. 2 (1978) 99-112.

144. J.D. Brunzell. Obesity and coronary heart disease - a target approach. Arteriosclerosis 4 (1984) 180-182.

145. R.J. Garrison et al. Cigarette smoking as a confounder of the relationship between relative weight and long-term mortality. J.A.M.A. 249 (1983) 2199-2203.

146. S. Rossner. Risks of overweight and the benefits of weight reduction. Acta Med. Scand. 215 (1984) 1-3.

147. E.L. Barrett-Connor. Obesity, atherosclerosis, and coronary artery disease. Ann. Intern. Med. 103 (1985) 1010-1019.

148. R.J. Garrison and W.P. Castelli. Weight and thirty-year mortality of men in the Framingham study. Ann. Intern. Med. 103 (1985) 1006-1009.

149. P. Bjorntorp. Regional differences of fat distribution. Ann. Intern. Med. 103 (1985) 994-995.

150. M. Krotkiewski et al. Impact of obesity on metabolism in men and women - importance of regional adipose tissue distribution. J. Clin. Invest. 72 1150-1162 (1983).

151. R.K. Kalkhoff et al. Relationship of body fat distribution to blood pressure, carbohydrate tolerance, and plasma lipids in healthy obese women. J. Lab. Clin. Med. 102 (1983) 621-627.

152. D.J. Evans et al. Relationship of body fat topography to insulin sensitivity and metabolic profiles in premenopausal women. Metabolism 33 (1984) 68-75.

153. W.H. Mueller. The biology of fat patterning In: N.G. Norgan Human body composition and fat distribution: report of an EC work shop, London 10-12 December 1985 Euro-nut report; 8 Wageningen, 1987, pages:159-174.

154. A.F. Roche, R.N. Baumgartner, S. Guo. Population methods: anthropometry or estimations In: N.G. Norgan Human body composition and fat distribution: report of an EC work shop, London 10-12 December 1985 Euro-nut report; 8 Wageningen, 1987, pages:31-47.

155. B. Larsson et al. Abdominal adipose tissue distribution, obesity, and risk of cardiovascular disease and death: 13 year follow up of participants in the study of men born in 1913. Br. Med. J. 288 (1984) 1401-1404.

156. L. Lapidus et al. Distribution of adipose tissue and risk of cardiovascular disease and death: a 12-year follow up of participants in the population study of women in Gothenburg, Sweden. Br. Med. J. 289 (1984) 1257-1261.

157. N.G. Norgan and A. Ferro-Luzzi. Principal components as indicators of body fatness and subcutaneous fat patterning. Hum. Nutr.: Clin. Nutr. 39 (1985) 45-53.

158. P. Ducimetiere, J. Richard and F. Cambien. The pattern of subcutaneous fat distribution in middle-aged men and the risk of coronary heart disease: the Paris Prospective Heart Study. Int. J. Obesity 10 (1986) 229-240.

159. J.C. Seidell et al. Fat distribution of overweight persons in relation to morbidity and subjective health. Int. J. Obes. 9 (1985) 363-374.

160. J.C. Seidell, K.C. Bakx, P. Deurenberg, J. Burema, J.G.A.J. Hautvast, F.J.A. Huygen. The relation between overweight and subjective health according to age, social class, slimming behavior and smoking habits in Dutch males. Am. J. Publ. Health 76 (1986) 1410-1415.

161. J.C. Seidell et al. Associations of moderate and severe overweight with self-reported illness and medical care in Dutch adults. Am. J. Public Health 76 (1986) 264-269.

162. K.J. Cureton and P.B. Sparling. Distance running performance and metabolic responses to running in men and women with excess weight experimentally equated. Med. Sci. Sports Exercise 12 (1980) 288-294.

163. W.D. McLeod, S.C. Hunter, B. Etchison. Performance measurement and percent body fat in the high school athlete. Am. J. Sports Med. 11 (1983) 390-397.

164. E.J. van der Beek en M. Wedel. Overgewicht en lichamelijk prestatievermogen van HOOS-cursisten TNO-CIVO-rapport nr. V85.292/230002, 1985.

165. R.P. Elam. Body fat and its relationship to tibial nerve conduction velocity in a specific population. J. Orthop. Sports Phys. Ther. 8 (1987) 495-497.

166. J.A. Vogel et al. An analysis of aerobic capacity in a large United States population. J. Appl. Physiol. 60 (1986) 494-500.

167. B. Leelarthaepin, E. Chesworth and T. Boleyn. Physical performance, physical activity and body fatness. J. Food and Nutrition 40 (1983) 164-169.

168. R.A. Binkhorst, J. Heevel and A.M. Noordeloos. Energy expenditure of (severe) obese subjects during submaximal and maximal exercise. Int. J. Sports Med. 5 (suppl.) (1984) 71-73.

169. J.K. Thompson et al. Exercise and obesity: etiology, physiology and intervention. Psychological Bulletin 91 (1982) 55-79.

170. K.D. Brownell. Behavioral, psychological, and environmental predictors of obesity and success at weight reduction. Int. J. Obes. 8 (1984) 543-550.

171. J.S. Garrow. Physiological aspects of exercise in relation to obesity. Int. J. Sports Med. 5 (suppl.) (1984) 66-68.

172. F. Grande. Impact of food restriction a physical performance. In: Predicting decrements in military performance due to inadequate nutrition. Proceedings of a workshop, pp 81-97 Nat. Academy Press, Washington D.C., 1986.

173. K.H. Cooper et al. Physical fitness levels vs selected coronary risk factors - a cross-sectional study. J.A.M.A. 236 (1976) 116-169.

174. T.E. Brown, W.S. Myles and C.L. Allen. The relationship between aerobic fitness and certain cardiovascular risk factors. Aviat. Space Environ. Med. 54 (1983) 543-547.

175. J.N. Morris et al. Vigorous exercise in leisure-time: protection against coronary artery disease. Lancet 1980,ii: 1207-1210.

176. R.F. Gillum et al. Longitudinal study (32 years) of exercise tolerance, breathing response, and blood lipids in young men. Arteriosclerosis 1 (1981) 455-462.

177. R.E. LaPorte et al. The spectrum of physical activity, cardiovascular disease and health: an epidemiologic perspective. Am. J. Epidemiol 120 (1984) 507-517.

178. A.R. Folsom et al. Leisure time physical activity and its relationship to coronary risk factors in a population-based sample -The Minnesota Heart Study. Am. J. Epidemiol. 121 (1985) 570-579.

179. E. York, R.E. Mitchell and A. Graybiel. Cardiovascular epidemiology, exercise, and health: 40-year follow up of the U.S. Navy's "1000 Aviators". Aviat. Space Environ. Med. 57 (1986) 597-599.

180. R.S. Paffenbarger et al. Physical activity, all-cause mortality, and longevity of college alumni. N. Engl. J. Med. 314 (1986) 605-613.

181. J.N. Morris et al. Exercise and the heart Lancet 1981, i: 267.

182. R.A. Washburn and H.J. Montoye. The assessment of physical activity by questionnaire. Am. J. Epidemiol 123 (1986) 563-576.

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CHAPTER 6

ALIMENTATION OF MILITARY CASUALTIES

6.1 INTRODUCTION

320. After effective shock control and successful surgical treatment, continuous alimentation is often of major importance to further prognosis; this of course depends on the seriousness of the injury. Depending on the degree of seriousness, each injury produces characteristic endocrine and metabolic changes summarized under the term "postaggression syndrome". It is determined by a predominance of catabolic-action hormones. Glycolysis, lipolysis, and gluconeogenesis are increased, while substrate utilization and immunodefence are decreased and speedy development of a negative nitrogen balance occurs. This negative nitrogen balance is generally regarded as being particularly serious because it is difficult to neutralize even in the case of optimum treatment. A potential cause for this may be found in the forced setting at rest of the casualty resulting in significant losses of protein from the musculature and thus producing a deterioration of the catabolic situation of the metabolism. Delayed healing, infection, and muscular respiratory insufficiency constitute major complications from the surgeon's point of view. The objective of alimentation must include the restoration and/or preservation of body substance and of the immunological system as well as the prevention of complications caused by alimentary factors (1,2,3).

6.2 FORMS OF NUTRITION

321. Alimentation of wounded persons can be effected in the following modes:

Oral feeding

- **Normal diet**
- **Light diet** — prepared and cooked under careful conditions (for example, no fried meat/fish or fried potatoes, no flatulence causing food items), in case of individual food incompatibility.
- **Therapeutic diet** — in cases of metabolic disorder such as kidney insufficiency (protein restricted diet), pancreatitis, diabetes mellitus.

Tube-feeding diet

- Self-preparation
- Formula diet
- Elementary diet

Parenteral feeding

- Via peripheral vein
- Via central vein

6.3 TYPE OF SUPPLY

322. The choice of feeding modes, which in peacetime is primarily determined by medical criteria, must in wartime, through necessity, also consider technological, organizational and other personnel related aspects. Thus, for the preparation of a normal, light, therapeutic and tube-feeding diet, only such fresh and dietetic food that can be procured within the constraints of food rationing as well as foods from the war reserves which are suited for patient feeding, may be available.

6.4 TUBE FEEDING

323. Whether a gastric, or better, a duodenal tube can be placed under stethoscope or roentgenological control with the aid of the laryngoscope must be left to the respective situation (4). Frequent changing of the tube for the prevention of ulcerations has turned out to be superfluous. Feeding should be effected at intervals by administering portions which should not exceed 100 milliliters in the case of a duodenal tube but may amount to as much as 200 milliliters in the case of the gastric tube. Self-prepared tube-feeding diets, too, should be administered immediately and should in no case be stored for more than 2 hours to avoid hygiene risks. Essential for successful tube-feeding is a slow, gradual increase of the feeding rates because the enzymes with their short biological half-life, which are necessary for digestion, are particularly affected by the destructive metabolism and must first be formed again by way of a slow process. In tube-feeding, diarrhea constitutes a complication which in the majority of cases, however, is not due to an infection but to inadequate fluid administration, in the case of hyperosmolar tube-feeding diets. If necessary, the prevention of this complication requires the administration of larger fluid quantities. The occurrence of extensive reflux happens in the case of brain injuries and polytraumas necessitates the discontinuation of tube-feeding and the transition to parenteral feeding (5,6).

324. If the preparation of a tube-feeding diet from conventional foodstuffs is not feasible or not indicated due to the seriousness of the injury, the administration of a commercial

- Formula diet

or

- Elementary diet

must be considered.

325. The administration of a formula diet, characterized as a nutrient-defined food concentrate, requires intact resorptive conditions, because due to its composition, absorption is possible only after enzymatic splitting. In the case of an elementary diet as a chemically defined diet where the nutrients are present as amino acids, monosaccharides and oligosaccharides, fats and essential fatty acids, the food need not be broken down, i.e.; it is reabsorbed completely. Therefore it is particularly indicated for all forms of resorptive disturbances (7).

326. There is no clear differentiation between the indication for a tube - feeding diet or parenteral feeding so that a decision, especially under wartime conditions must be made from case to case.

6.5 PARENTERAL NUTRITION

327. Whilst it may be possible, circumstances permitting, and in the case of a minor injury, without serious catabolism (destructive metabolism), to meet the nutrient and agent requirements via a peripheral vein access, the necessary concentration of the feeding fluid and the resulting osmolarity closely restrict this access in the case of major injuries. The reason for this is vein intolerance of solutions in excess of 1000-1200 mosm/kg of water. A 20% glucose solution has an osmolarity of 1250 mosm and, thus, is not suited for prolonged peripheral vein feeding. While as a rule the energy requirement of casualties set at rest probably amounts to 1500 - 2500 kcal/day, the requirement in cases of raised body temperature, burns, sepsis, and brain injuries may even exceed 3000 kcal/day. An average rise of the energy requirement by 15% is assumed for one degree of raised body temperature. An increase of 25-45% has been described in the case of sepsis and of 100% in the case of burns. Meeting the energy requirement is subject to restrictions due to the utilization rates and external factors, respectively (6,8,9).

328. The fats, which also are of importance to an adequate energy supply, should not be given before postaggression syndrome subsides. This is possible with newly developed fat emulsions with a shelf life of two years at room temperature of not more than 25°C. The value for fat amounts to 1 - 1.5 g/kg of body weight per day (10-14).

6.5.1 Examples of Parenteral Nutrition

329. For standardized parenteral feeding, war reserves should be based upon the following three-stage concept:

Stage 1: Substitution of water and electrolytes with carbohydrate additions for a maximum of two days.

Stage 2: Peripheral-vein basal alimentation with 40 ml per kg of body weight per day of a solution containing about 37.5 g amino acids and about 50 g of carbohydrates per liter in addition to the electrolytes; for a maximum of four additional days.

For technological and biological reasons, polyols should be used as carbohydrates. Increased water and electrolyte losses must additionally be considered. If at least partial enteral alimentation is not feasible after a total of six days, the following central-vein basal alimentation is recommended.

Stage 3: 40 ml per kg of body weight per day of a solution containing, at least, 37.5 g of amino acids and 125 g of carbohydrates per liter. By way of exception and limited by venous tolerance, this solution is also suitable for peripheral-vein application on a short-term basis if nonglucose carbohydrates and/or polyols are used.

Stages 2 and 3: The calculated daily dose of the present solution should provide adequate amounts of vitamins and other essential nutrients. The danger of infection in case of indwelling intravenous catheters requires special attention.

6.6 SUMMARY

330. Continued scientific and technological improvements in the quality of proper nutrition of injured/wounded personnel have resulted in major improvement in patient care. The ability to provide all necessary nutrients in the form of diets especially via tube feeding and partly, in cases with disorders in which alimentary disfunction precludes adequate nutrition, by total parenteral nutrition, has sustained lives or prevented serious disease.

7.7 REFERENCES

1. Weiner, R., Hartig W. Postoperative kunstliche Ernahrung. Klinik Journal Nr. 5/6: 10-14, 1986

2. Meyers A., Zaloga G.P., Malnutrition in Hospitalized Patients. US Navy medicine Vol 77, No 4: 3-7, 1986

3. Dolp R., Grunert A., Bohm A. Enterale oder parenterale Ernahrungstherapie Infusionstherapie 10: 286-290, 6/1983

4. Rabast U. Lokalisation von Ernahrungssonden. Deutsche medizinische Wochenschrift 110: 1074-1076, 1985

5. Hackl, J.M., Eder Ch., Kolfer J. und Murer J. eflux und Stuhlfrequenz bei kunstlicher Ernahrung von traumatisierten Intensivpatienten Infusionstherapie 11: 305-312, 6/1984

6. Mosebach, K.O., Caspary R., Hausmann D., Stockel H. Erprobung neuerer endokrino- und anaesthesiologischer Erkenntnisse bei der kunstlichen Ernahrung Schwerverletzter. Forschungsbericht aus der Wehrmedizin. BMVg - FB WM 87-4

7. Hammann V. Ernahrungstherapie durch Sondenernahrung - eine aktuelle ubersicht. Ernahrungs-Umschau 34: 327-330, 10/1987

8. Vogel W., Wehmer H., Leins R. und Kluthe. Langzeitanalyse des Aminosauren- und Eiweibstoffwechsels nach schwerem Polytrauma. 1. Mitteilung. Aktuelle Ernahrungsmedizin 2: 47-53, 1979

9. Kluthe R., Betzler H., Vogel W. Langzeitanalyse des Aminosauren- und Eiweibstoffwechsels nach schwerem Polytrauma. 2. Mittelung. Aktuelle Ernahrungsmedizin 10: 4-13, 1985

10. Georgieff, M. Intravenose Ernahrung - Moglichkeiten und Grenzen der Anwendung von Glucose und Xylit nach Trauma und Sepsis unter besonderer Berucksichtigung des Leberstoffwechsels. Infusionstherapie 14: 93-97, 3/1987

11. Ekman L., Wretlind A., Moldawer L. New Developments in Lipid Emulsions for Parenteral Nutrition. Infusionstherapie 14: 4-8, 3/1987

12. Eckart J., Adolph M. Verwertung von Kohlenhydraten und Fett in der postoperativen Phase. Aktuelle Ernahrungsmedizin 4: 158-172, 1979

13. Eckart J., Adolph M., van der Muhlen U. und Naab V. Fat Emulsions Containing Medium Chain Triglycerides in Parenteral Nutrition of Intensive Care Patients. Journal of Parenteral and Enteral Nutrition 4: 360-366, 1980

14. Jelen-Esselborn S., Tempel G. v. Hundelshausen B. Fettemulsionen in der parenteralen Ernahrung. Infusionstherapie 10: 152-158, 3/1983

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CHAPTER 7

RATIONS OF SELECTED NATO COUNTRIES - PURPOSE AND NUTRIENT COMPOSITION

7.1 INTRODUCTION

331. The aim of this chapter is to describe, in some detail, the various types of packed rations used by NATO forces and to comment on the composition and nutritional value of those rations. It should be noted that all countries are in a continual process of improving their rations and that the following descriptions should be considered only as a snapshot.

332. NATO STANAG 2937 outlines the fundamental principles that should form the basis of the various types of rations used in the NATO countries. Compliance with the STANAG should therefore ensure that the rations of the armed forces of the member countries are nutritionally sufficient and have a satisfactory shelf life. Furthermore, the implementation of the STANAG by all member countries should permit one nation to help another in situations, for example, where lines of communication become disrupted or in other emergency situations.

333. STANAG 2937 identifies three different categories of rations:

- survival rations
- emergency rations
- combat rations

334. These rations have different purposes and are planned for different periods of continuous use and are hence of different composition in regard to energy content and nutritional value.

7.2 SURVIVAL RATIONS

335. In accordance with STANAG 2937, survival rations are designed for situations where the main concern is to stay alive with a minimal expenditure of energy and where drinking water is limited. They should be as small as possible in volume and consist of at least 100 grams of carbohydrate (glucose or glucose-forming poly-, oligo- or disaccharides) per man per day.

336. This type of ration should provide the soldier with immediately utilizable energy without requiring much water, but at least 500 ml per man per day should be available. In order to avoid the requirement for additional water, they should not be supplemented with any protein or fat.

337. The shelf life of survival rations should be at least 4 years at ambient temperatures.

338. Only a limited number of NATO countries are currently producing survival rations, and some countries do have them in their systems.

7.2.1 Canada

339. Canada has three types of survival rations:

- Food Packet, Survival, Basic
- Food Packet, Survival, Supplementary, Air
- Food Packet, Survival, Supplementary, Maritime

340. The Basic Survival Food Packet is the survival food packet for land, sea and air, and complies with the STANAG. The Supplementary Air and Maritime Packets are considered purely as supplements to the Basic Survival Food Packet and their use is optional.

341. The Basic Survival Food Packet is intended to provide emergency level sustenance for a period of two days. The packet contains starch jellies which are high in caloric density and have a long shelf life. The jellies do not induce thirst and therefore are beneficial under conditions of water shortage. Each packet contains a number of starch jellies (flavours: for example, orange and lemon). The weight of each packet is approximately 285 g and contains 3375 kJ (806 kcal). The Supplementary Air and Maritime Food Packets provide extra energy, mainly in the form of powders for hot drinks.

7.2.2 United Kingdom

342. The United KIngdom has two types of survival rations intended for different scenarios:

- 25 Man Life Raft
- Submarine escape stores

343. Each 25 man life raft carries 3 drums of stores. In these are packed:

- 184 packets - each of 37.5 g barley sugar
- 100 tins - each of 385 ml water

344. Assuming 25 men in each life raft and no food or water for the first day, this gives a four day survival period on 513 ml water and 92 g carbohydrate per man per day.

345. The submarine escape stores are located in the escape compartments of Royal Navy Submarines. One pack comprises:

- 24 x 37.5 g packets of barley sugar
- Water is held in tanks

346. The quantity held depends on the size of the boat and the size of the crew. Sufficient is held to supply 100 g carbohydrate and 500 ml water per man per day for 7 days.

7.2.3 United States

347. The United States have three types of survival rations:

- Food Packet, Survival, General Purpose.
- Food Packet, Survival, Abandon Ship.
- Food Packet, Survival, Aircraft, Life Raft.

348. The Food Packet, Survival, General Purpose is suitable for use in any survival situation under all environmental conditions, including those where potable water is limited. The ration contains four food bars of uniform nutrient content, sugar, coffee powder and a soup and gravy base. The bars contain some protein that is rigidly controlled, so that the food packet conserves body water yet assures maximum value from the protein at any level of consumption. The Food Packet is packaged in a 12-ounce rectangular can and it contains 2930 kJ (700 kcal), 8% provided from protein, 28% from fat and 64% from carbohydrate.

349. The Food Packet, Survival, Abandon Ship is supplied to lifesaving craft aboard ships. It consists of two starch jelly bars, mint tablets, chewing gum and matches. Each packet provides 1985 kJ (475 kcal).

350. Food packet, Survival, Aircraft Life Raft, used in life rafts of naval aircrafts, is intended for short term use while awaiting rescue or airdrop of supplies. It contains two bars of fruit tablets and two packets of chewing gum. The energy provided by one packet is 1250 kJ (300 kcal).

351. From the description of the survival rations it seems evident that such provisions are intended for use only for short periods. The lack or shortage of protein and fat can only be tolerated for short periods. Additionally, the very low content of dietary fibre may cause trouble after some days. The shortage of certain vitamins is less important for a period of up to two weeks, if the diet prior to the use of the survival rations has been sufficient. A summary of the content of NATO survival rations is given in Table 7.1.

Table 7.1 A Summary of the Energy Content, Shelf Life and Weight of Survival Rations.

Country	Energy (kJ)	Shelf Life (years)	Weight (g)
Canada	3375	5	285
United Kingdom			
(life raft)	1540	6	92
(submarine)	1675	2	100
United Sates			
(gen purpose)	2940	3	360
(abandon ship)	1985	3	145
(life raft, aircraft)	1250	3	88

7.3 EMERGENCY RATIONS

352. An emergency ration is the subsistence calculated to sustain the operational capability of military personnel for a brief period of time (at least 24 hours) in the event that the regular food supply is disrupted. Water is assumed to be freely available (STANAG 2937).

353. The emergency ration should be as small as possible in volume and should consist of concentrated foods with an energy value of at least 4.2 MJ (1000 kcal), to be provided in approximate portions of 40-70% from carbohydrates, 20-40% from fat and 10-20% from protein. The ration should be suitable for consumption without cooking, heating or the addition of water. The inclusion of instant beverage powders, for example, tea or coffee, is desirable. Water treatment tablets should also be available, but need not be included with the emergency ration. The emergency ration should have a shelf life of at least 2 years at ambient temperatures.

354. Most NATO countries have emergency rations in their system. The distinction between survival rations and emergency rations can be difficult. According to the given definitions the major difference is the contents of fat and protein in the emergency ration compared to the presence of only carbohydrate as an energy source in the survival ration.

7.3.1 Belgium

355. Belgium has emergency rations of four menu varieties. The composition (average 6070 kJ (1450 kcal), distributed as 13% protein, 40% fat and 47% carbohydrate), conforms with the recommendations of STANAG 2937.

7.3.2 Canada

356. Canada is developing a new ration called "Light Meal Combat" which will comply with the specification for the emergency ration. Although still in the developmental stage, it will, tentatively, be comprised of dried fruits, dried processed meat, dried cheese, hot chocolate beverage mix, orange beverage mix, candies and granola bars.

7.3.3 Denmark

357. Denmark has been using the American Long Range Patrol Ration, which is now out of production. The Food Packet Assault will be used in the future, but only for specialized units such as parachutists and assault divers. Emergency rations are not produced in Denmark at present, but a "pemmican-like" product to be used by the Sirius Sledge Patrol in North-Eastern Greenland is under development.

7.3.4 Germany

358. Germany has developed a new single variety emergency ration. It is vacuum packed in aluminium foil and consists of 8 bars, each weighing 26 g, of concentrated nutrients supplied with 2 packets of tea-extract and water purification tablets for two litres of water.

359. The German ration weighs approximately 225 g, 15 g being the packing material. It is carried by German soldiers in the field as part of their standard equipment. The caloric content is 4200 kJ (1000 kcal) provided from 14% protein, 26% fat and 60% carbohydrate. As can be seen from these figures the German Emergency Ration has been designed according to the recommendations of STANAG 2937.

7.3.5 Netherlands

360. The Netherlands have recently introduced a new emergency ration with a composition that conforms with the recommendations of STANAG 2937. It consists of bars of concentrated nutrients, weighs 200 g and has an energy content of 4200 kJ (1000 kcal). The shelf life of the Dutch emergency ration is 5 years.

361. The American Long Range Patrol Ration has been used by specialized units of the Dutch Army and will probably be replaced by the American Food Packet Assault.

7.3.6 Norway

362. Norway has an emergency ration consisting of two components: one box of tinned meat stew and one packet of compressed food of baked wheat, vegetable protein, vegetable fat, saccharose and glucose. The total energy content is approximately 6865 kJ (1640 kcal) broken down as 17% protein, 44% fat and 39% carbohydrate. The total weight is 480 g and the shelf life set at 10 years.

7.3.7 United Kingdom

363. The United Kingdom has one emergency ration, the Emergency Flying Ration Mk. 9. It consists of two aluminium alloy containers, which can be used as cooking pots, vacuum packed together in laminate foil. They contain:

- 2 emergency food packs, each comprising 250 g in eight portions providing 4200 kJ (1000 kcal) in the proportions of 10% protein, 16% fat and 64% carbohydrate.
- 1 packet beef stock drink cubes.
- 1 packet beverage powders (7 coffee, 4 tea and 7 vegetable fat creamers) and salt (6 sachets), 2 spatulas,
- one 1 litre polythene bag,
- an instruction leaflet.

364. It is recommended that approximately 1.5 l water per man per day is taken with this ration.

7.3.8 United States

365. The United States have introduced the Food Packet Assault, which is a compact, lightweight food packet of high nutrient density for individuals in non-resupply situations. It is designed for use for up to ten days at the rate of one packet per person per day. It is based on technological advances in freeze drying and compression, and meets the requirements of the Marine Corps, that volume and weight should be at a minimum and still maintain operational effectiveness.

366. There are 6 different menus for the Food Packet Assault which on average contain 6360 kJ (1520 kcal), 16.2% provided from protein, 31.2% from fat and 52.6% from carbohydrate. All menus can be eaten dry but many will rehydrate to give a familiar entree, dessert or beverage. Each packet contains the entree, a granola bar, cookies, chocolate, sweets, orange beverage, instant coffee, cream substitute, sugar, a spoon, mixing bag,

chewing gum, matches and toilet tissue.

7.3.9 Summary

367. The contents of NATO Nations Emergency rations are given in Table 7.2.

Table 7.2 A Summary of the Nutritional Composition, Shelf Life and Weight of Emergency Rations

Country	Nutrients				Shelf Life (years)	Weight (g)
	Energy (kJ)	Protein (%)	Fat (%)	Carbo-hydrate (%)		
Belgium	6070	23	40	47	4	800
Canada	4200					
Germany	4200	14	26	60	5	225
Netherlands	4200	15	30	55	5	200
Norway	6865	16.7	44.2	39.1	10	480
United Kingdom	4200	10	26	64	5	500
United States	6360	16.2	31.2	52.6	5	350

368. As can be seen from Table 7.2 all types of emergency rations conform to the guidelines of STANAG 2937. It is generally accepted that fat should only provide a maximum of 35% of the daily energy intake. This is not completely fulfilled in all the emergency rations, but due to the fact that these rations are only meant for use for short periods and often under extreme conditions this seems to be of minor importance. In fact it should be noted that the "pemmican-like" ration that is under development for use in Northern Greenland will have approximately 60% of the energy from fat. This is in response to a demand from the soldiers serving in that extremely cold environment. A parallel might be drawn to the fact, that most psychrotrophic (cold-loving) bacteria are very active in the break down of fats, probably producing poly-unsaturated fatty acids that have a lower melting point than the more saturated ones.

369. The contents of dietary fibre in the emergency rations has not been mentioned, because these rations are not meant for use over long periods. Hence the rather low contents of fibre will probably lead to no or very limited digestive problems, for example, constipation or the development of haemorrhoids.

370. The United States are developing a Ration, Light Weight - 30 days (RLW-30), which can be considered somewhere between an emergency ration and a combat ration. It is a calorie restricted ration containing 8400 kJ (2000 kcal) per man per day and has been developed to meet the weight and volume restrictions for prolonged patrol missions, of up to 30 days, without resupply. The ration has been tested under field conditions and has proven useful for conditions of light to moderate physical activity.

7.4 COMBAT RATIONS

371. The individual combat ration must ensure the complete and wholesome subsistence of a soldier for one day, but would not be expected to be used for more than 30 consecutive days. It should have a minimum of 13.4 MJ (3200 kcal) and a maximum commensurate with the rate of energy expenditure for service personnel undergoing continuous and strenuous physical activity (STANAG 2937).

372. The protein content of the individual combat ration should provide at least 10% of the available energy, i.e. 80 g of protein for a ration pack of 13.4 MJ (3200 kcal). At least 50% of the protein should be derived from animal (not vegetable) sources, i.e. protein of high biological value. Fat should account for approximately 35%, but must not exceed 40% of the total energy value. Vitamins and minerals should be broad agreement with the recommendations of Chapter 2. If fortification is required, the nutrients should be added to those items most likely to be consumed by the personnel.

373. The individual combat ration should contain ready-to-eat dishes which can be consumed without the addition of water, preparation or mixing and, if necessary, without heating. The standard contents of an individual combat ration should, in addition, include: a bread equivalent and a suitable topping or spread (for example, jam, sausage, cheese) and instant beverage powder, for example, coffee, tea, fruit beverage). The individual combat ration must have a shelf life of at least 2 years at ambient temperature.

374. All NATO countries have in their system combat rations that are adapted to meet the food habits and food preferences that country. Several countries have more than one type of combat ration as, for geographical or strategic reasons, soldiers may be expected to operate in different environments and situations. Special attention must be given to these situations, not only in terms of taste and presentation, but also in terms of energy requirements and composition.

375. The following provides examples of the many types of combat rations and should give an idea behind the nutritional and gastronomic thinking of the various countries. It should be noted that not all of the countries have approved or implemented STANAG 2937.

7.4.1 Belgium

376. Belgium has one type of individual combat ration with 8 different menus. In all menus the morning and evening meals consist of biscuits, marmalade, chocolate, sweetened condensed milk, sugar, instant coffee, salt, drinking syrup, acid drops, napkins, plastic bag and matches. The mid-day meal is a powdered soup.

377. The average energy content of the 8 menus is 17.1 MJ (4080 kcal) with 11.9% provided from protein, 27.9% fat and 60.2% by carbohydrate. The energy content is rather high compared to the STANAG, but the fat content is extremely low.

7.4.2 Canada

378. Canada has Individual Meal Packs (IMP) that are issued to individuals for consumption during training and operational commitments, where fresh rations are not available. No preparation other than heating or the addition of hot or cold water is required.

379. Each IMP contains pouched and packaged food items in sufficient quantity to provide one meal with between meal beverages. There is an average of 4940 kJ (1200 kcal) in each meal pack. A six day menu series provides a variety acceptable for continuous use for periods up to 30 days. There are 4 types of breakfast IMPs, 6 types of lunch IMPs and 6 types of supper IMPs. One breakfast, one lunch and one supper IMP plus between meal beverages taken during a 24 hour period provide 14.8 MJ (3600 kcal). Total weight of the 3 IMPs is 1900 g. All meals contain biscuits; jam, marmalade, honey or peanut butter; coffee or tea; sugar, whitener, chewing gum, candy, salt and pepper. Breakfast contains a meat dish such as a ham omelette, a cereal, fruit beverage crystals and hot chocolate powder. Lunch and supper contain a meat dish, cherry cake or fruit, fruit beverage crystals or dehydrated soup; potatoes, rice or dressing and cookies or chocolate bar.

380. The IMP can be supplemented with a Ration Supplement, Tropical, which is issued to provide a basis for increased consumption of liquids by servicemen operating in tropical environments. It consists of sufficient commercial fruit beverage powder to make 682 ml per person per day. It can also be supplied with an Arctic Supplement. This supplement provides individuals subsisting on the IMP with additional nutrients and fluids they require when operating in arctic environments. It consists of sufficient commercial items to provide approximately 3275-4200 kJ (780-1000 kcal). The Arctic Supplements are authorized for local purchase and consist of hot chocolate powder and canned loaf or granola bars.

7.4.3 Denmark

381. Denmark has a combat ration system that is based completely on commercial products. A 24 hour ration consists of 4 different units, F-1, F-2, F-3 and F-4 (F = Field ration). The total energy content is 15.9 MJ (3800 kcal) with 12.5% provided from protein, 42% from fat and 45.5% from carbohydrates.

382. F-1 has a shelf life of 5 years and consists of canned and powdered products. F-2 has a shelf life of 6 months, F-3 is a tube of margarine with a shelf life of 6 months under refrigeration. F-4 is rye bread, which is locally purchased. This bread has a shelf life of 2-3 weeks.

383. There are 14 types of F-1, depending on the main ingredient, the canned dinner. F-1 contains the canned dinner, a meat spread, coffee powder, tea powder, refreshment towel, multipurpose napkins, matches, sugar and chocolate powder. F-2 consists of fish or meat spread, salami, cheese spread, marmalade, stewed fruit, mashed potato powder, rye biscuits, soup powder, chocolate bar, chewing gum, salt, pepper and a disposable toothpaste impregnated toothbrush.

384. The weight of the Danish combat ration is 2150 g. It can be seen from the description that the STANAG 2937 requirement of a shelf life of at least 2 years can only be met by the F-1 ration, which in itself is not sufficiently nutritive. The idea is that all operational units have in their stocks F-1 rations to bring with them immediately, and that F-2, F-3 and F-4 rations can be provided from central stocks within, at most, 24 hours. The size and topography of Denmark should be taken into consideration in this connection.

7.4.4 Germany

385. Germany has two types of combat rations; one type for preparation in field kitchens according to feeding plan A, the other, feeding plan B, the individual combat ration.

386. Individual combat rations are designed for use in situations where central cooking or field kitchens are not available. In order to meet the criteria of weight shelflife most of the ingredients are produced solely for use in the armed forces.

387. The average individual combat ration provides 15.3 MJ (3650 kcal), 11% of the energy from protein, 40.4% from fat and 48.6% from carbohydrate. The shelf life is at least 3 years and the weight is approximately 1500 g.

388. There are four different types of individual combat rations. Variety is provided by varying the composition of entrees and spreads in the Dorsch cans (Flex-cans).

389. The individual combat ration consists of an entree and a meat dish with vegetables, a spread of meat, fish or cheese, vitamin fortified margarine, biscuits, marmalade, coffee powder, tea powder, sugar, whitener, salt, chocolate, vitamin fortified fruit beverage powder, chewing gum, water purification tablets, multipurpose paper, plastic pouch, refreshment towel, matches and a description paper.

390. A special type of combat ration has been designed for use in submarines, where exercise is very limited and there is an inherent risk of overeating. For this reason more menu varieties (for example 14 types of entrees) are provided for use in submarines. The shelf life of the submarine ration is one year.

7.4.5 Netherlands

391. The Netherlands have various types of combat rations. The Interim Ration is supplied to mobilization centres having no cooking facilities (schools and other large buildings), when the supply of fresh food is not possible. It can also be used on arrival at the fighting area when the field kitchens are not yet ready for use. It is a 24 hours ration. The main meal is easy to heat in a short time (centrally as well as individually), hot drinks can be prepared centrally and also in small groups. All the other components, such as biscuits, marmalade and cheese can be distributed individually.

392. The individual combat ration is designed for issue in any tactical situation. Breakfast and lunch are supplied in one box and the main course in a 400 g Dorsch-can (a Flex-can type). This makes a complete 24 hours ration for one individual. There are 7 dinner menus and the shelf life is 3 years.

393. The 24 hour individual combat ration comprises a Dorsch-can with the main course, meat spread, cheese spread, biscuits, marmalade, instant beef broth, instant soup, instant coffee, tea powder, lemon flavoured beverage powder, sugar, whitener, chocolate bar, vitamin fortified dextrose tablets, fruit flavoured candy, salt, chewing gum, matches, and paper tissues. The energy content of the Dutch individual combat ration is 17 MJ (4060 kcal).

7.4.6 Norway

394. Norway is at present reformulating its combat rations. The work is not yet finished but it is intended for there to be two packs, pack A containing items with a shelf life of more than 5 years and Pack B with items having a shelf life of less than 2 years.

395. Most of the items in the two packs will be commercially available products. The A pack will consist of a dehydrated meal for a hot lunch, a Flex-can dish for dinner, biscuits, Brixbits (bars with chocolate or fruit taste) and accessories, for example, matches, paper tissues, can opener and

a multivitamin-tablet.

396. Pack B will contain margarine, various spreads, chocolate bar, instant soup, instant coffee, instant tea, hot chocolate powder and a powdered beef broth.

397. The energy content is intended to be at least 14650 kJ (3500 kcal), and the composition will follow the guidelines of STANAG 2937. In extremely cold environments the A and B packs can be supplemented with an extra Brixbit (4600 kJ (1100 kcal)).

7.4.7 United Kingdom

398. The United Kingdom has two major types of combat rations: one designed to feed both large and small groups, and the other to feed individual soldiers. The combat rations for group feeding are packed for 4 and 10 men. They shall not be described in detail.

399. Individual combat rations are of 2 types:

- 24 Hour General Service (GS) Ration,
- 24 Hour Arctic Ration.

400. The 24 hour GS ration is produced in four menu varieties and designed to provide sufficient food for one man for one day. It is normally issued with an individual hexamine cooker. The ration weighs approximately 1.6 kg and is designed for consumption for up to seven consecutive days. Most items are packed in flexible containers although a number of cans are also used.

401. A typical menu would include biscuits, oatmeal blocks, a bacon breakfast, beef spread, dextrose tablets, sweets, "Rolo" chocolate, soup powder, a meat main course, (for example, steak and kidney pudding, spaghetti in sauce), a fruit dessert, fruit filled biscuits, tea bags, instant coffee, instant skimmed milk, sugar, a beef stock drink, salt, chewing gum, matches, can opener, toilet paper and a list of contents.

402. The mean nutritional value of the 24 hour GS Ration is 16600 kJ (3970 kcal) with 10.8% being provided from protein, 28.9% from fat and 60.3% from carbohydrate.

403. The 24 Hour Arctic Ration, intended for use in a cold environment, is similar in concept to the 24 Hour GS Ration, except that all contents, less the spread, are dehydrated or packed in flexible containers. It weighs approximately 1.4 kg. The 24 Hour Arctic Ration provides 11.5% of the energy from protein, 24.4% from fat and 64.1% from carbohydrate giving a total of 18620 kJ (4450 kcal). The main reason for the higher energy content, compared to the 24 Hour GS Ration, is the addition of extra sweets.

7.4.8 United States

404. The United States have combat rations for small groups of personnel called Tray Packs. These contain different types of entrees, vegetables, salads, starches, breads and desserts. They can be prepared in the container and thus reduce the need for chefs.

405. Since 1983, the individual combat ration for US forces has been the Meal, Ready-to-Eat (MRE). The MRE provides individual meals containing food components that are ready to eat and highly acceptable, even when consumed under conditions precluding preparation, except reconstitution of beverages. The MRE is suitable for use in the combat zone and under all circumstances where resupply is established or planned, but where operational conditions preclude other means of subsistence.

406. The Meal, Ready-to-Eat has 12 menus, each providing an entree, crackers, a spread, dried fruit or cakes, beans in tomato sauce or potato patties or cocoa beverage powder, coffee, cream substitute, sugar, salt, chewing gum, matches and toilet tissue. Some also include candy or an additional condiment.

407. The average energy content of the MRE is 5.1 MJ (1200 kcal) with 14.1% being provided from protein, 40.9% from fat and 45% from carbohydrates. The MRE has a very long shelf life and weighs 380 g. A 24 hour ration is composed of 3 MREs and thus contains 15.3 MJ (3660 kcal). Water is required for the rehydration of the dehydrated products, but in a situation where a shortage of water exists, the dehydrated items can be eaten without the addition of water.

408. In response to data from prolonged feeding trials which indicated low consumption of some MRE items, a new improved MRE was developed, tested and procurement initiated in 1988. Primary changes include increasing the portion sizes and caloric content of the entrees and adding a powdered fruit beverage and bottle of hot sauce to each meal. The caloric content of three meals has been raised to 16490 kJ (3939 kcal) distributed as 14% from protein, 33% from fat and 53% from carbohydrates. Like the MRE the Improved MRE has 12 menus. The sodium content of the Improved MRE has also been reduced. The decision to procure the new MRE was based upon the results of field trials comparing the old and new MRE which indicated that the changes increase acceptability and consumption of the ration.

Table 7.3: A Summary of the Nutritional Composition, Shelf Life and Weight of Combat Rations

Country	Nutrients						Shelf Life (years)	Weight (g)
	Energy (kJ)	Protein (%)	Fat (%)	Carbohydrate (%)	Vitamins *	Minerals *		
Belgium	17100	11.9	27.9	60.2	+	+	4	2000
Canada	14800	13	29	58	+	+	3	1900
Denmark	15900	12.5	42	45.5	+	+	4	2150
Germany	15300	11	40.4	48.6	+	+	3-5	1500
Netherlands	17000	11	39.5	49.5	+	+	4	1700
Norway	14650				+	+	2-5	
U.K.								
(24 Hr.GS)	16600	10.8	28.9	60.3	+	+	2	1600
(Arctic)	18620	11.5	24.4	64.1	+	+	2	1400
U.S.A.								
(Old MRE)	15300	14.1	40.9	45	+	+	4	1150
(New MRE)	16490	14.0	33.0	53.0	+	+	4	1435

+ vitamins and minerals contents conform to recommendations of Chapter 2.

7.5. CONCLUSIONS AND RECOMMENDATIONS

409. Dietary Fibre has not been included in Table 7.3 due to the lack of a uniform definition. Nevertheless, it is still necessary to be aware of the need for dietary fibre in combat rations that are designed for use for up to 30 consecutive days. In accordance with current recommendations, the daily intake of dietary fibre should be between 30-35 g found from cereals and vegetables. A shortage of dietary fibre over a longer period may have an incapacitating effect on many individuals leading, for example, to constipation and eventually haemorrhoids.

410. The gross weight of the Danish combat ration is considered to be too high and the percentage of energy obtained from fat excessive when compared with the recommended 35%. Introduction of freeze-drying techniques in the future will overcome the latter problem.

411. The US combat ration, MRE, is also considered to provide too much energy from fat although this problem has now been resolved with the introduction, in 1988, of the Improved MRE which provides 33% of its energy from fat.

412. It must be a aim of all member courtries to slowly modify their combat rations so as to conform to the internationally accepted guidelines. This may prove to be a difficult process as food habits and food customs are hard to change and, as discussed in Chapter 8, consumer acceptability must be given a very high priority in order that good nutritional intentions are not wasted.

413. In regards to the interchangeability of the rations between nations, the nutritional requirements are standard and should not therefore represent a problem. The area where problems will occur is in taste and consumer acceptability in that the contents of each individual country's rations are carefully adapted to the specific taste of that country. On the other hand, in an emergency, taste is less important than sufficiency and there is no doubt that in a situation of shortage or where supplies have been interrupted, reliance will need to be placed on alternative supplies obtained from NATO partners. This reliance should apply not only to the nutritional aspects, but should also cover the hygiene aspects during production, storage and handling.

414. STANAG 2937 gives some guidelines concerning the basic requirements of field rations for the armed forces of NATO. A continued cooperation between the specialists of these countries will ensure, that the nutritional aspects of military feeding will be highlighted and kept up to date at all time by all member countries.

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CHAPTER 8

GARRISON AND COMBAT FEEDING - OPTIMIZING AND EVALUATING CONSUMPTION

8.1 INTRODUCTION

415. The ultimate objective in military feeding is to provide the soldier with a healthy, balanced diet, to stated nutritional criteria, which is of maximum acceptability and within the constraints of availability, logistics, cost and other economic factors. When consuming combat rations this can be further expanded so as to ensure that any combat feeding structure is capable of maintaining or increasing a soldier's performance and behavioural effectiveness by providing him with a diet where consumption is maximized and wastage minimized.

416. However it is a well understood and often stated principle that food not nutrients are consumed so no matter how nutritionally well balanced a diet actually is, it is only of value if actually consumed. Attempts to train all but specially selected soldiers to consume, out of barracks, any item of food with equanimity even when hungry have been unsuccessful and it is only when a soldier likes the food will it actually be consumed. Providing soldiers with combat rations which are popular, and evaluating consumption is therefore an essential component to any field feeding system. This basic principle has been established from observations and field trials conducted under a variety of situations in different environmental conditions and during the Second World War on American, British and Canadian soldiers where it led to the conclusion that:

> "Planners of future packaged rations should profit by the field experience of ration trials in the war. Palatability and acceptability should come first" (1).

417. The importance of improving and monitoring combat ration acceptability was recognized at the first workshop meeting of this Group where extended sessions were devoted to the subject. It was identified, in many facets, as a topic requiring further study and member nations were encouraged accordingly.

418. Monitoring the nutritional intake of various population groups is an essential feature of any food management system. This is even more important for military populations in that it provides a baseline of information to fulfil a number of criteria:

* Ascertain how closely dietary intakes compare with Recommended Dietary Allowances (RDAs) and dietary goals.
* Ascertain the nutritional intake derived from combat rations.
* Provide data to determine what corrective action is needed.
* Monitor the effects of change created by various nutritional strategies.

8.2 TECHNIQUES AVAILABLE TO MEASURE FOOD PREFERENCE AND FOOD ACCEPTANCE

419. One of the best ways of predicting whether people will eat a food, or how much of it they will eat, is to ask them how well they like it (2). The methodologies available to monitor and assess food preferences were reported in the first workshop meeting. These were later summarized in the Netherlands Military Medical Journal (3).

420. The most commonly used test is the Hedonic Scale. This can be traced back for over 150 years but its application to food evaluation techniques did not occur until the 1920s. Modern development was undertaken in 1947 by the Quartermaster Food and Container Institute of America (4) and through a process of independent experiments modified and developed into its current format.

421. The Hedonic Scale consists of a number of statements anchored around a neutral point. The categories vary on either side of the neutral point progressing up and down in a continuum of like and dislike. The number of categories are not important and the layout of the scales may be either horizontal or vertical commencing with either like or dislike (5). Opinions differ on the total number of categories required, the maximum normally being nine and, although as low as two have been used, five is the minimum number recommended (6). Each category is then assigned a descriptive term, the scale arranged into a questionnaire and a number of food items administered to test subjects.

422. This method has limitations insofar as only a limited number of food items may be tried and tested at any one time before a loss of concentration occurs; up to 20 for mild products (7). An alternative method is to ask participants to respond to word stimulation where up to 60 items may be tried before any evidence is shown of careless answering of the questions (4).

423. Although the Hedonic Scale has value in predicting whether a specific food item will be consumed, the scale is much less reliable in predicting the total consumption of a mixed meal or a days ration, especially over an extended period of time. For example, items that are given high ratings at a dinner meal may not be consumed very frequently if served with a breakfast meal.

8.3 TECHNIQUES AVAILABLE TO MEASURE NUTRITIONAL INTAKE

424. Assessing the nutritional status of individuals or populations can be undertaken using a wide range of direct and indirect methods. Dietary surveys are one such instrument, the methodology for which has been reviewed by a number of authors. The methods considered most suitable to measure the dietary intake of military personnel are briefly as follows:

8.3.1 Methods Suitable for Use with Individuals

8.3.1.1 Food Diary

425. A diary is maintained for a specific period of time, for example, 3 to 7 days, during which time volunteers record all items of food and drink consumed. Where possible actual weights or sizes are recorded together with amounts left unconsumed.

8.3.1.2 Recall

426. Volunteers recall, either through interview or questionnaire, all food and drink consumed over a specific period, for example, 24 hours. Weights or amounts consumed are estimated by reference to known portion sizes or duplicate samples.

8.3.1.3 Dietary History

427. A trained interviewer questions volunteers on their normal or regular feeding patterns and habits over a long period of time. Gradually a profile can be established on what constitutes a regular feeding pattern.

8.3.1.4 Food Frequency

428. A trained interviewer questions volunteers to ascertain the frequency with which food groups are eaten. Over time and with the use of statistical techniques, average consumption can be estimated.

8.3.1.5 Weighed Intake

429. Volunteers are asked to weigh and record all food and drink consumed over a particular period, 3 to 7 days. Alternatively, duplicate meals are prepared simultaneously which are then weighed.

8.3.1.6 Visual Observation

430. Data collectors are trained to estimate the portion size of food items taken and refused (plate waste) by visual comparison to a weighed standard portion of each food item. With training, calorie consumption at a meal can be accurately estimated to within an error of ± 2% (8). This method and it reliability have been discussed in further detail (9).

8.3.2 Methods Suitable for Use with Groups

8.3.2.1 Food Account

431. Details of food and drink purchased over a specific period are calculated. By taking into account opening and closing stocks, total consumption can then be calculated.

8.3.2.2 Recall

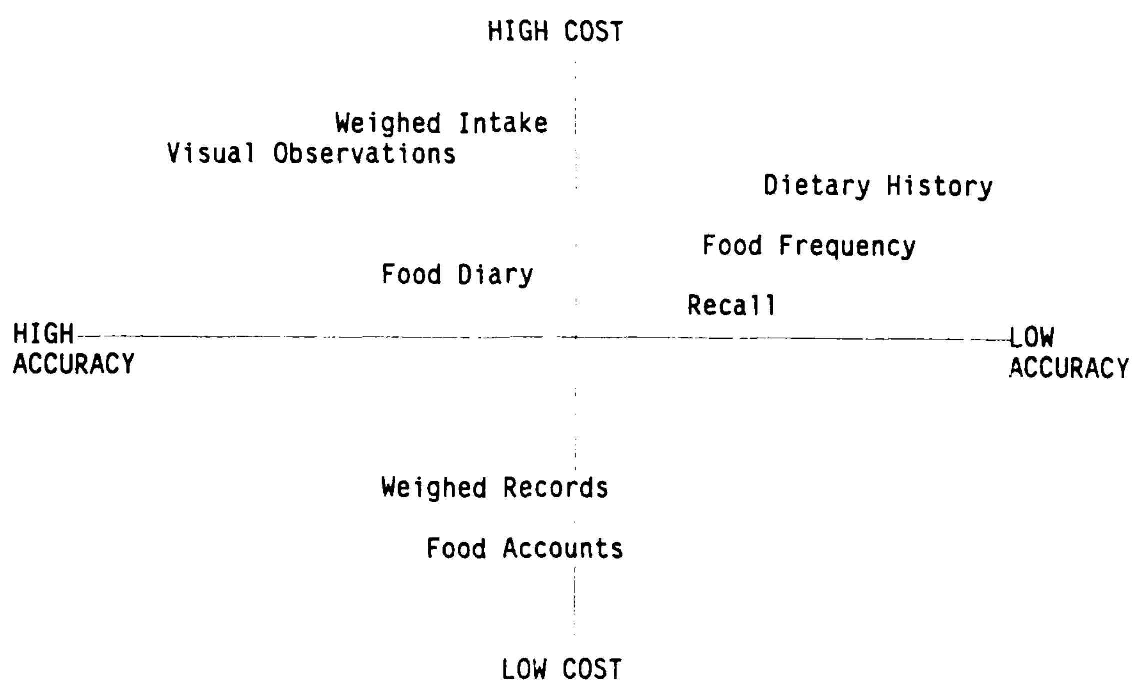
432. Total quantities of food are estimated through interview with those personnel responsible for the purchase or preparation of food.

8.3.2.3 Weighed Records

433. Food and drink consumed over a specific period are weighed. Reference is then made to opening and closing stocks after which total consumption can be calculated.

434. Despite the wide range of techniques available no single one represents an ideal, each having advantages and disadvantages in terms of finance, time and the co-operation of individuals involved (Figure 8.1).

Figure 8.1 Diagrammatical Layout Showing The Relationship Between Accuracy and Resources Required for Dietary Surveys



435. During the course of this Panel's work, a number of questionnaires and techniques were developed to measure food preferences and nutritional intake derived both in Garrison feeding and from combat rations. Although only selected aspects can be reported here, it is considered of value, for future reference, to record a number of the questionnaires actually used. These are attached at Annex I and referenced in the text.

8.4 EMPIRICAL RESEARCH UNDERTAKEN INTO COMBAT RATION FEEDING SITUATIONS

8.4.1 United Kingdom

436. Little work has been undertaken in the United Kingdom to assess the food preferences, food acceptance and nutritional intake derived from combat rations whilst actually in service and it only during the initial stages of development of a new ration pack that any effort is made to gauge opinion. Even here though, the number of subjects, the total number of days of consumption and the conditions under which consumption takes place are always limiting factors. In order to correct this situation a small research project was undertaken to provide a baseline of information and establish the suitability and effectiveness of a food preference evaluation programme.

8.4.1.1 Postal Survey

437. Included in a postal surveyed (Annex II) administered to 3109 officers and soldiers in the United Kingdom were questions concerning the importance of certain factors when eating individual combat rations. Using a five point scale - Essential through High, Medium, Low Importance to Not Important - respondents were asked to rate attributes associated with the design of pack and food. These factors were then given values 100, 75, 50, 25 and 0 with 100 being assigned to Essential and 0 to Not Important.

8.4.1.1.1 Results

438. A summary of the results is given in Table 8.1.

Table 8.1 The Rating in Importance of Certain Factors Connected with the Design of Individual Combat Rations

Factor	Importance Index
Pack	
Easy to carry in pouches	87
Light weight	81
Food	
Easy to heat or cook	89
Sufficient quantity to eat	88
Minimum of preparation	88
A healthy balanced diet	86
Easy to eat	79
Food to taste good	75
To like the food	67
Wide variety of food	59
Familiar not strange food	56
To look appetizing	50

8.4.1.2 Field Surveys

439. Using the Hedonic Scale a number of questionnaires were developed around a seven point scale using terms ranging on both sides of the neutral point as follows:

Like Very Much	7	Dislike Very Much	3
Like Moderately	6	Dislike Moderately	2
Like Slightly	5	Dislike Slightly	1
Neither Like nor Dislike	4		

440. In addition a five point scale, ranging from 'All' through 'None' was added to ascertain how much food was actually consumed; other questions were also included in order to stimulate comment and to explain why certain items of food might not only have been rejected but thrown away.

441. The questionnaires developed, were pre tested and piloted and further modifications made. They were then administered to personnel immediately on their return to the United Kingdom after the Falkland Islands conflict and, following further modification, during the annual winter exercise conducted in Norway. The final questionnaire developed is given in Annex I.

442. In total, 417 questionnaires were completed for the 24 Hour GS Ration and 592 for the 24 Hour Arctic Ration. Less than 2% were discarded as being thought unrepresentative of the sample or to have been carelessly or frivolously completed. A statistical analysis was then carried out in order to rate the preference of each food item and on which to draw conclusions.

443. Whilst it is impossible to define one particular point on a scale above which food items are considered acceptable and below which are unacceptable, such results do give a clear indication as to whether further research is required in the provision of more suitable items. Table 8.2 shows a summary of the preference ratings of food items found in the 24 Hour Arctic Ration which are typical of those obtained from other packs.

Table 8.2 A Summary of the Preference Ratings of Food Items Found in the 24 Hour Arctic Pack

Overall Order of Pref	Total Valid Cases n	Food Item	Grand Totals		Falkland Is.		Winter Ex.	
			Hedonic Value	SD	Hedonic Value	SD	Hedonic Value	SD
1	223	Chocolate Biscuits	6.7	0.9	6.7	0.9	-	-
2	584	Milk Chocolate	6.4	1.1	6.7	0.7	6.2	1.2
3	580	Drinking Chocolate	6.2	1.6	6.6	1.1	6.0	1.8
4	582	Rolled Oats	6.2	1.5	6.5	1.2	6.0	1.7
5	583	Rolo	6.2	1.3	6.6	0.9	5.9	1.5
6	590	Instant Coffee	6.1	1.6	6.5	1.2	5.8	1.7
7	347	Sugar	5.7	1.6	-	-	5.7	1.6
8	586	Nuts and Raisins	5.5	2.0	5.8	1.8	5.3	2.1
9	587	Fruit Biscuits	5.4	1.7	6.0	1.4	5.0	1.8
10	522	Mutton Granules	5.4	1.7	5.6	1.7	5.2	1.7
11	534	Beef Granules	5.3	1.7	5.6	1.8	5.1	1.7
12	586	Curry Beef Granules	5.3	2.0	5.4	2.0	5.2	1.9
13	583	Beef Stock Drink	5.2	2.0	5.7	1.7	4.9	2.2
14	589	Milk Powder	5.1	1.9	5.7	1.7	4.7	1.9
15	572	Beef Spread	5.1	2.0	5.8	1.6	4.5	2.0
16	548	Chicken Supreme	5.1	2.1	5.7	1.7	4.6	2.2
17	347	Salt	5.0	1.7	-	-	5.0	1.7
18	564	Pre cooked Rice	4.9	2.0	4.9	2.2	5.0	1.8
19	580	Apple Flakes	4.9	2.4	5.2	2.3	4.7	2.2
20	536	Ham Spread	4.9	2.0	5.7	1.6	4.3	2.1
21	565	Chicken Spread	4.9	2.0	5.7	1.6	4.3	2.0
22	573	Potato Powder	4.9	2.0	5.4	1.9	4.5	2.0
23	550	Chicken/Bacon Spr.	4.8	2.0	5.5	1.7	4.3	2.1
24	583	Dried Peas	4.8	2.0	5.0	2.1	4.6	2.0
25	553	Apple/Apricot Flks	4.6	2.4	5.0	2.4	4.4	2.3
26	305	Chicken Soup	4.6	2.3	4.6	2.3	-	-
27	589	Instant Tea	4.5	2.3	5.8	1.9	3.6	2.3
28	551	Oxtail Soup	4.4	2.2	4.6	2.4	4.1	2.0
29	588	Dextrose Tablets	4.2	2.2	4.7	2.2	3.9	2.2
30	564	Vegetable Soup	4.2	2.2	4.5	2.3	3.9	2.0
31	582	Plain Biscuits	3.4	2.2	4.1	2.0	2.9	1.9

\- Not Available
SD Standard Deviation

8.4.1.2.1 Significant Findings

(a) Food Preferences and Food Acceptance

444. In the majority of responses, significant differences, better than five per cent, were found for the preference-acceptance of individual food items between the variables Rank, Marital Status, Age/Years of Service and Number of Days of Consumption: to some extent this grouping should be expected as some are inter related. It however indicates that young single soldiers respond differently to their older married counterparts. The value of approaching older, senior and experienced personnel to ascertain the views of the majority is questionable. The requirement is for views from a broad representative but weighted sample. In general different units respond in a similar way with nearly 40% of the food items obtaining similar rankings.

445. When comparing the mean Hedonic values obtained from the Falkland Islands and the exercise, it can be concluded that, at a significance level better than five per cent, units respond in a similar manner both during exercises and under operational conditions.

446. In general terms the combat rations are acceptable but on both occasions a number of items were thrown away. This was particularly relevant on the Falkland Islands where they contributed to the only source of food and where energy expenditure was likely to be higher than normal. A number of personnel reported being hungry and losing weight, but still chose to discard various food items. Where items were thrown away during the Falkland Islands conflict, these have been given a value of 0 and the results recalculated. An extract is given in Table 8.3.

Table 8.3 Least Popular Items Found in the 24 Hour Arctic Rations

Commodity	Percentage of Personnel Grading Food Items: 0 Thrown Away, 1 Dislike Very Much, 2 Dislike Moderately	Percentage of Personnel Grading Food Items: 0 Thrown Away
Vegetable Soup	27.23	20.85
Plain Biscuits	25.85	11.02
Chicken Soup	25.64	20.94
Oxtail Soup	25.32	21.10
Apple & Apricot Flakes	24.56	14.04
Dextrose Tablets	22.86	12.24
Pre cooked Rice	21.19	11.86
Apple Flakes	19.09	11.20
Dried Peas	16.10	7.63
Curry Beef Granules	13.33	4.29

447. The most common reason for throwing items away was "Have eaten it before and didn't like it" where almost 57% of respondents gave this reason. The other major reason for not consuming food centred on the difficulty or inconvenience of preparation. The time and facilities available for food preparation under operational conditions are severely limited. Unless food is easy to prepare and reheat it is likely to be discarded. This is amply illustrated by the soup powder which unlike the instant "Cup of Soup" varieties requires five minutes stirring and simmering.

448. Menu monotony was commented upon by many respondents. The 24 Hour Arctic Ration is provided in four menu varieties. Whilst this may be adequate when the full variety is provided, this was not always the case and the same packs were often issued on consecutive days. The problem was compounded by the similarity between the menus in the different combat rations.

449. Packaging was criticized heavily particularly in the 24 Hour GS Ration. The flexible packaging used in the Arctic packs was considerably more popular than the cans in the other ration packs. Many soldiers reported throwing items away or eating them at the point of issue rather than carry them. In part this was because of the weight of the cans but mainly because of fears of inflicting personal injury when hitting the ground when enemy contact was made.

450. Further comments were also made on items that soldiers would like added to the rations: these included more beverage items, including a fruit drink, more chocolates and more easily prepared foods.

(b) Nutrition and Morale

451. Failure to consume all or part of the food items in a nutritionally planned and balanced diet has implications for the health and morale of the individual soldier and for logistics and finance. This applies particularly when the combat ration represents the only source of food over a long period as it did in the Falkland Islands.

452. Nutritional intake on the winter exercise was calculated using mean values of the amounts of food consumed. A summary of these results for the Arctic pack are presented in Table 8.4 along with the Recommended Dietary Allowances from Chapter 2. Similar calculations were also made for the GS Ration. Whilst these results can only provide a broad indication of the nutritional intake as, for example, food items which were 'swapped' are not included, it does provide a better understanding of the nutritional value derived from the current range of packs.

Table 8.4 A Summary of the Nutrients Provided and Estimated Consumption from the 24 Hour Arctic Ration

Nutrient	Unit	Amount Provided	Amount Consumed	Variation		Recommendations Chapter 2
				Unit	%	
Energy	kcal	4448	3660	788	17.7	3600
	MJ	18.6	15.3	3.3	17.7	15.0
Protein	g	133.2	108.8	24.4	18.3	100
Fat	g	125.9	108.0	17.9	14.2	160
Carbohydrate	g	742.0	600.6	141.4	19.1	440
Sodium	mg	9368	6770	2598	27.7	1100-3300
Calcium	mg	2637	2183	454	17.2	800-1200
Iron	mg	23.6	19.4	4.2	17.8	18
Vitamin D	mcg	-	-	-	-	5-10
Thiamin	mg	11.4	7.6	3.9	34.2	1.6
Riboflavin	mg	6.7	5.46	1.24	18.5	1.9
Nicotinic Acid	mg	24.9	19.6	5.3	21.3	21
Vitamin C	mg	40.65	31.24	9.41	23.1	60
Vitamin A	mcg	292.9	256.8	36.1	12.3	1000
Percentage of Energy from:						
Fat	%	25.5	26.6	-	+1.1	-
Protein	%	12.0	11.9	-	-0.1	-
Carbohydrate	%	62.4	61.5	-	-0.9	-

453. Although these recommendations may not be strictly valid due to the higher energy expenditure associated with performance in an Arctic environment they do provide a broad indication for comparative purposes. The average consumption of all nutrients apart from Vitamins A and D are within the RDAs. Vitamin A was below the recommendations as insufficient is provided in the pack. Clearly this is a situation that needs to be addressed. The shortfall in Vitamin D is also of some concern, particularly in view of the low dietary intake in barracks. Nicotinic Acid and Vitamin C may also provide concern especially when combat rations are consumed for any length of time. A further more recently expressed concern is the high salt content. Salt requires water for excretion and where this may be limited it is likely to have an adverse effect on health.

454. Between 12 and 34% of nutrients are being lost to the soldier because food is not being consumed. If it can be proved that the non-consumption of some food items, particularly those shown in Table 8.3, is not detrimental to the nutritional intake of the soldier, then they might be considered as superfluous and their continued retention unnecessary. If however, loss of essential nutrients from the daily diet of the active soldier can result from his "throwing away" food items that he does not like, research should be directed towards producing a ration pack where consumption is more assured. Food aids morale but only when it is liked and consumed; preference is indicative of consumption (10). In order to establish the relationship between a soldier's liking for food items and the amount actually consumed, correlation coefficients were calculated for the mean hedonic values and the mean amount consumed. Resulting coefficients all demonstrate a positive correlation at greater than one per cent level. A soldier's liking for particular foods is indeed indicative of consumption.

(c) Logistics and Finance

455. Military activities, like all other activities involving resources, require finance and planning. The futility of moving rations from a base to an operational area only for all or part of them to be discarded is obvious.

8.4.1.2.2 Conclusions

45C. The results of the study indicate an overall acceptance of most of the food items supplied in the combat rations but a number of items are definitely consider to be unpopular. In some instances this unpopularity was so great that items were discarded rather then be consumed. In most cases the prime reason for this situation was because of a dislike of the item. Food preferences operated under both exercise and operational situations.

8.4.1.2.3 Implications

457. Until this research was undertaken it had been planned that combat rations in their current format would continue to be used well into the next century with only small modification being made to the actual content. As a result of this research a number of changes have been made or are proposed for both the medium and longer terms.

(a) Medium Term:

Additions/Modifications to the 24 Hour GS Ration
Modified "New Recipe" biscuit
Substitution of soup powder for instant "cup of soup" varieties
Additional drinks - coffee, tea
Additional breakfast - rolled oats
Inclusion of water sterilizing tablets

(b) Long Term:

Replacement of canned items with retort pouches
Replacement of individual components, ie meat, vegetables and potatoes with a complete meal
Replacement of milk powder with coffee whitener

8.4.2 United States

458. The United States has for a number of years had a regular and on-going programme designed to evaluate food preferences, food acceptance and the nutritional intake derived under different combat feeding scenarios and are generally regarded as the leaders in these fields of research.

459. Studies have been conducted over a number of years the more important of which during the tenure of this RSG are summarized below:

8.4.2.1 The Effects of Prolonged Feeding Meal Ready to Eat (MREs) Operational Rations

460. Current scenarios call for troops to subsist on operational rations as their sole source of food for extended periods of time but it is not known whether or not this could be done without compromising their effectiveness. Accordingly a field study into the effects of prolonged feeding of MREs was conducted on an extended field training exercise (34 days) with troops from the 25th Infantry Division of the Pohakuloa Training Area on the big island of Hawaii during August and September 1983 (11).

461. Despite its high acceptability and the troops' satisfaction, the MRE was not consumed in sufficient quantity. Daily calorific intake average 2189 kcal (9.2 MJ) for the MRE group and 2950 kcal (12.3 MJ) for

the control group. Both values are considerably below the recommended level of 3,600 kcal (15.1 MJ) for the very active soldier (Chapter 2). The MRE group showed a decline in daily calorific intake over the course of the field test, whereas daily calorific intake tended to remain stable in the control group.

462. The low food intake did not appear to be due to dissatisfaction with the sensory properties of the ration (taste, smell, appearance) or to thirst-induced anorexia. Water intake of the MRE group was somewhat lower than that of the control group (2657 ml/day versus 3132 ml/day), but was not low enough to produce increased reports of thirst or significant changes in the monitored indices of body fluid status (urine volume, urine osmolality, hematocrit and hemoglobin). Rather, the low food intake in the MRE group appears to result from several factors, including loss of appetite, absence of scheduled meals, small portion size of highly rated and consumed entree items, lack of breakfast items in the ration and the limited variety of beverages in the ration.

463. The major consequences of the low food intakes were body weight loss and some vitamin and mineral intakes that were below recommended levels. The majority of troops in both companies lost weight during the 34-day field test (69 of 71 in the MRE company and 57 of 68 in the control company), but the men in the MRE company lost significantly more weight than those in the control company (8.1 lbs (3.7 kg) versus 4.6 lbs (2.1 kg)). Both groups had intakes of niacin and magnesium below the recommended levels, while the MRE group also had intakes of riboflavin, calcium and iron below recommended levels.

464. The other measurements that were taken to evaluate any effects of prolonged feeding the MRE or any possible effects of nutritional deficiencies that developed did not reveal any major differences between the two companies. The questionnaire data on the incidence of physical symptoms showed that the two groups had similar profiles of complaints and discomforts during the field tests, but of the 67 possible symptoms on the questionnaire, the two reported at the highest frequency were: "I feel good" and "I feel alert". There were, however, two important food related symptoms that were reported at a higher frequency by the MRE group. The MRE company reported that they had lost their appetite and that they experienced gas pressure more frequently than the control group. The MRE company did not differ from the control company on any of the six mood scales and both companies showed a considerable improvement in their mood scores during the field test. In a similar manner, the two companies did not differ from one another on measures or morale and perceptions of leadership. These latter ratings were positive and remained stable over the four data collection points.

465. The performance of the troops in the two companies did not differ on a test battery of cognitive and psychomotor tasks. The test battery included tasks which measured eye-hand coordination, speed of gross arm movements, accuracy and speed of aiming at stationary and moving targets, reaction time, memory scanning rate, short term memory capacity, speed and accuracy of coding digits into symbols, grammatical reasoning and the speed

and accuracy with which simple arithmetic problems are solved. Within the MRE company, the performance of the individuals who lost the most weight (greater than 7% body weight loss) did not differ from the performance of those who lost the least amount of weight during the field test.

466. Despite the low levels of food intake, nutritional status (as indexed by measures of hemoglobin, hematocrit, plasma albumin, plasma total protein, serum vitamin C, serum folate, plasma pyridoxal phosphate, serum retinol and serum zinc) did not reveal significant differences between the two companies or values that were outside the normal range. Plasma albumin and total protein were consistent with adequate protein status. Values for serum vitamin C were normal throughout the field trial. Values for retinol were at the upper range of normal levels. Serum folate values fell during the field test in both companies, but in neither company did this value fall below normal limits. Plasma pyridoxal phosphate concentrations remained unchanged during the field test in the control company, but rose above normal levels in the MRE company. Serum zinc remained within normal limits in both companies. With the one exception that troops fed solely the MRE lost more weight than troops fed two hot meals daily, the data on selected blood constituents indicate that nutritional status was not compromised by subsistence on the MRE for 34 days.

8.4.2.2 Nutritional Evaluation of a New Combat Field Feeding System for the Army.

467. The most comprehensive test and evaluation ever of a Combat Field Feeding System (CFFS) was conducted with approximately 1650 soldiers from the 25th Infantry Division engaged in field training exercises at Pohakuloa Training Area (PTA), Hawaii during a seven week period beginning in August 1985 (12,13). The purpose of this test was to determine if the innovative food technologies employed in the proposed new CFFS would significantly reduce the combat food service requirement for labour (cooks), water, fuel, food preparation time and feeding operations. Furthermore, it was specifically directed that the test design evaluate the nutritional and bio-medical effects of prolonged (6 - 7 consecutive weeks) consumption of the new T (tray pack) ration meals as compared to the standard B and A rations.

468. The nutritional and bio-medical issues addressed in this study were as follows:

* Nutrient Consumption
* Energy Balance
* Hydration Status
* Nutritional Status
* Food Related Health Disorders
* Muscle Strength and Eye-hand Coordination

469. To evaluate these issues, forty volunteer test subjects from each of six test units participating in the CFFS were briefed on all data collection procedures. Baseline (pre) bio-medical measurements were taken before breakfast 4-6 days prior to deployment of the units to PTA. The measurements included demographics, height, weight and body composition. Urine analyses included specific gravity, osmolality, creatinine, sodium, potassium and chloride. Blood analyses included hematocrit, hemoglobin, total protein, sodium, potassium, magnesium and biochemical indices of vitamin A, vitamin C, thiamin, folic acid and iron status. Blood lipid analyses included triglycerides, total cholesterol and high density lipoprotein (HDL) and low intensity lipoprotein (LDL) cholesterol. The incidence of gastrointestinal symptoms was assessed with the USARIEM Environmental Symptoms Questionnaire and by monitoring sick call logs. Muscular performance was assessed by measurement of handgrip force and endurance, maximal upright pull force and maximal lift capacity. Eye-hand coordination was assessed by an arm-hand steadiness test and a ball-pipe test. Essentially all of these measures were repeated at the beginning (T + 1), middle (T + 20) and end (T + 44) of the 44 day period.

470. Total daily food and water consumption data were obtained on 16 of the 44 days using a combination of observation, interview and self-reporting diary techniques. Nutrient composition and food consumption data were combined to compute nutrient consumption. To facilitate rapid data reduction all of the approximately one million nutrition and bio-medical data points were entered into a computerized data base and verified on site.

471. During the study units consumed differing mixes of T, B or A rations and Meal Ready to Eat (MRE) rations according to the schedule at Table 8.5. No other sources of food were available.

Table 8.5 Ration Schedule

Test Group	Unit	Test Day 1 - 3	4 - 7	8 - 21	22 - 44
1T	Artillery Btry	3 MRE	1T/2 MRE	1T/2 MRE	1T/2 MRE
1TF	DISCOM (females)	3 MRE	1T/2 MRE	1T/2 MRE	1T/2 MRE
2T	Artillery Btry	3 MRE	1T/2 MRE	2T/1 MRE	2T/1 MRE
2TE	Artillery Btry	3 MRE	1T/2 MRE	2T/1 MRE	2T/2 MRE (enhanced
2B	Engineer Co	3 MRE	2B/1 MRE	2B/1 MRE	2B/1 MRE
2A	Artillery Btry	3 MRE	2A/1 MRE	2A/1 MRE	2A/1 MRE

472. All test units were engaged in meaningful training throughout the study. The temperature in August and September was mild (average high and low temperatures were 68°F (20°C) and 48°F (9°C) respectively): measurable rainfall occurred on only one day. The average elevation is 6000 ft (1829 m).

473. The average daily nutrient intakes for each test group were compared with the Recommended Dietary Allowances (Chapter 2) for male and female personnel. The average daily energy intakes of all groups except 2A were below the RDA range of 3000-3400 kcal/day (12.6-14.2 MJ/day) and 2200-2600 kcal/day (9.2-10.9 MJ/day) for moderately active males and females, respectively. Group 2A consumed more ($p < 0.05$) energy (3047 kcal/day (12.7 MJ/day)) than any of the other male groups which averaged 2700 kcal/day (11.3 MJ/day). Energy intakes averaged only 2445 kcal/day (10.2 MJ/day) from the 3669 kcal (15.4 MJ) available during the first three days when all groups were consuming three MREs per day. These results were consistent with those of the previous prolonged (35 day) feeding test at PTA and confirm that troops fed solely three MREs per day do not consume sufficient quantities of food to meet the demands of even moderate levels of energy expenditure. Further analyses indicated that all male groups continued to consume only approximately two-thirds of the calories available in the one or two MRE portion of their respective ration mixes.

474. Average calorie consumptions at breakfast meals were similar for T (871 kcal (3.6 MJ)), B (765 kcal (3.2 MJ)) and A (958 kcal (4.0 MJ)) ration menus. However, calorie consumptions at T ration dinner meals were much lower (986 kcal (4.1 MJ)) than at B ration (1246 kcal (5.2 MJ)) or A ration (1501 kcal (6.3 MJ)) meals. A comparison of the calories available and actually consumed at T and A ration dinner meals (Table 8.6) identifies menu factors contributing to the differing calorie consumptions. T ration entrees and canned fruits (used as desserts) were well accepted but contained fewer calories per serving than A ration entrees and baked desserts. The T ration included spreads (MRE peanut butter, cheese spread) to increase caloric content but only 5% of the available calories from these spreads were actually consumed. Further analyses indicates that the soldiers liked and ate a high percentage of these same spreads with their MRE meals but did not want them with the T ration meal.

Table 8.6. Calories Available and Consumed at T Ration and A Ration Dinner Meals

	T Ration		A Ration	
	Calories Available (kcal)	Calories Consumed (%)	Calories Available (kcal)	Calories Consumed (%)
Entrees	245	91	398	108
Starches	250	70	172	54
Vegetables	43	62	102	65
Fruits/Pudding	114	74	90	31
Desserts	-	-	271	90
Salads	-	-	59	58
Dressings	-	-	153	65
Gravies	-	-	20	84
Breads	256	64	250	61
Spreads	337	5	29	65
Beverage Base	108	86	108	96
Milk	-	-	149	76
Cocoa powder	119	13	-	-
Condiments	34	23	34	6
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Total	1506		1835	

475. Protein intakes were adequate for males and the marginally low (67 g) protein intake for the female group is not of concern because the protein RDA is higher than the required level to reflect the usual protein consumption patterns of Americans and other NATO countries.

476. The fat intake of Group 2A (42% fat calories) exceeded the recommendations and was greater ($p < 0.05$) than all other groups. The lowest fat intake was observed in Group 2T (31% fat calories). The A ration menu included whole milk, butter, salad dressings, gravies and high fat desserts such as cakes. The T ration contains less fat because there was less fat in the entrees and the desserts were mostly canned fruits.

477. Calcium intakes of the 1TF (female) and 2T groups were below the RDA of 800 - 1200 mg/day. The low calcium intakes (577 mg/day) by females on the IT/2 MRE diet may not be adequate to maintain bone health and may lead to a greater risk for development of osteoporotic disease. Because of a lack of refrigeration, the T ration menu does not provide dairy products, such as milk, which are the primary sources of calcium in the diet. Females consuming 2T ration and 1 MRE meals per day would be predicted to have an even lower calcium consumption than observed in this study.

478. Iron intakes were adequate for the male groups. The iron intake of the female Group 1TF (12 mg/day) is considered adequate because of the high bioavailability of iron in the CFFS rations. The Surgeon General has recommended a goal of 1400 - 1700 mg sodium per 1000 kcal (4.2 MJ). All groups exceeded the upper limit of that goal by approximately 10%. Further analysis indicates that approximately 6% of the daily sodium consumption was derived from added salt (salt packets).

479. All groups met or exceeded the RDA for thiamin, riboflavin, niacin, vitamin B6, vitamin A and Vitamin C.

480. All groups were able to maintain body weights within the energy balance criterion of + 3% of initial body weight. Group 2A had the lowest incidence (8%) and Group 2B had the highest incidence (35%) of individual soldiers with weight losses exceeding 5% of initial body weight.

481. All groups were able to maintain their hydration status within the criterion that the average urine specific gravities of a unit should not exceed 1.030. Although acute dehydration was not a problem, there were indications that individual soldiers were not always optimally hydrated. At Schofield Barracks (pre), only 6-18% of the individuals had concentrated urine (S.G. >1.030). However, a very high incidence (40-60%) of concentrated urine occurred on day T + 3 when all test groups had consumed three MREs per day. A ration effect was observed thereafter when the incidence of concentrated urine for Group 2A and 2B rapidly returned to baseline levels whereas the groups fed T rations did not. The utilized T ration provided only the 7 oz (198 g) paper cup for dinner. Frequently, the cups developed leaks discouraging consumption of a second beverage. Recorded beverages consumption was less than at T ration meals than at A or B ration meals. Milk in one-half pint cartons was available with A and B ration meals and thus contributed additional fluids.

482. Biochemical assessment indicated that all ration groups were able to maintain their vitamin A, folic acid, and iron status. For age groups 19-29, a National Institute of Health Expert Group recently proposed that serum total cholesterol values less than 200 mg/dl are associated with low risk of coronary heart disease (CHD) whereas values greater than 200 mg/dl are associated with increasing risk of CHD. By Chi-Square test, a significant ($p < 0.05$) shift in distribution occurred in Group 2A where the percentage of the population at low risk of CHD decreased from 72% at pre to 34% at day T + 44.

483. It is generally agreed that high HDL values are associated with a lower risk of CHD and that HDLs will rise with increased physical (aerobic) activity such as running several times per week. The observed general decline in HDL values in all groups may have been due to the abrupt reduction of running activity. Some authorities suggest that the ratio of total cholesterol to HDL is a more sensitive risk indicator of CHD and that cholesterol: HDL ratios greater than 5.0 for males and 4.4 for females may be associated with an increased risk of CHD. The incidence of high ratios in Group 2A rose ($p < 0.02$) from 7% prior to deployment (pre) to 32% at T + 44.

484. As noted earlier, Group 2A (fed two A rations and one MRE) consumed 42% of their calories from fat. Furthermore, Group 2A consumed 770 mg cholesterol per day. All other groups had fat intakes less than 35% and their cholesterol intakes were below 300 mg/day. Most of the cholesterol was consumed at the A ration breakfast meal (563 mg/meal) because eggs were served at every meal and were selected by most individuals. These data suggest that the excessive fat and cholesterol content of the A ration meals combined with the decreased running activity may have contributed to the rise in serum total cholesterol, decrease in HDL and increase in cholesterol; HDL ratio observed in Group 2A. Such shifts in lipid profile are undesirable and, if continued for prolonged periods, will contribute to an increased risk of CHD.

485. The body composition data indicated that muscle mass was maintained in all groups and the any body weight losses were due primarily to losses of body fat. Body composition and energy consumption data were used to calculate estimated energy expenditures for the various test groups. The male groups expended approximately 3000 kcal/day (12.6 MJ/day) compared to approximately 2050 kcal/day (8.6 MJ/day) for females. These energy expenditures are equivalent to a low to moderate level of physical activity.

486. The incidence of food related health disorders was very low throughout. There were 1.6 days lost per 1000 man days for sick call due to gastrointestinal distress compared to 25.6 days lost per 1000 man days for sick call due to non-gastrointestinal distress. Self reported gastrointestinal complaints were lowest for Group 2A.

487. There was no evidence in any of the four muscle strength/endurance measurements and two eye-hand coordination test of any decrement as a result of dietary treatment over time.

488. In summary, soldiers fed CFFS rations consumed sufficient calories to maintain energy balance for light to moderate physical activity (3000 kcal (12.6 MJ)) for extended periods. Protein, vitamin and iron intakes were adequate for all rations. The T ration meals consumed contained much less fat and cholesterol than A rations. An undesirable rise in serum total cholesterol was noted in the group that ate two A rations and one MRE per day for 41 consecutive days. The T ration menus will require modification to assure adequate calcium intakes, especially for female personnel. Consumption at T ration meals can be increased and waste reduced by providing more of the calories as entrees and desserts and eliminating or reducing MRE spreads with T ration meals. Some problems with adequate consumption of the MRE, certain T ration components and fluids were identified for improvement and further field evaluation. Decreased aerobic (running) training activity during extended field training exercises may contribute to an undesirable decrease in serum high density lipoprotein (HDL) cholesterol.

8.4.2.3 Effects of 'A' Ration Meals on Body Weight During Sustained Field Operations

489. Combat rations are designed to provide sufficient energy and other nutrients to meet the nutritional demands and requirements of soldiers in the field. In spite of this, body weight loss has frequently been reported during field studies especially when troops are expected to subsist solely on packed rations. This body weight loss has been attributed to inadequate consumption of rations.

490. Food consumption and body weight data were collected from 31 soldiers in three artillery batteries involved in 8 days of sustained field operations consuming 3 hot A ration meals/day (14). The soldiers consumed an average of 3713 kcal/day (15.5 MJ/day) to produce an overall body weight gain of 0.8 kg during the 8 days. A comparison of these results with previous studies indicate that soldiers consume more calories and lose less body weight when served three hot A ration meals/day as opposed to a combination of the other rations. The data clearly indicate that soldiers served hot meals that they like and given time to eat these meals, will consume sufficient calories to maintain energy balance enduring sustained, physically demanding field exercises.

8.4.2.4 Nutrient Intakes and Work Performances of Soldiers During Seven Days of Exercise at 7,200 Feet Altitude Consuming the Meal Ready-to-Eat Ration

491. The Meal Ready-to-Eat (MRE) ration was fed ad libitum to a group of 15 soldiers for a period of 12 days (15). Ten of the 12 days were spent under field conditions at moderate (7,200 feet (2195 m)) altitude. Seven of the 10 days at altitude were exercise days wherein the soldiers ran a strenuous cross country course (9 - 11 miles) for 2 hrs/day. Calorific intakes were less than adequate for energy balance under these conditions. During the 10 day exercise period, soldiers consumed less than 67% of the calories recommended for energy balance. The soldiers lost 3% of their body weight, 10% of their body fat, and experienced a decline of 5% in their maximal aerobic capacity. Although calcium, iron and riboflavin intakes were suboptimal, the most potentially serious deficiency noted was the low 260 g/day intake of carbohydrate. No remarkable changes in blood chemistries other than an increased level of ketone bodies were noted. Although the MRE ration supported a reasonable level of performance under these conditions it is recommended that the ration be supplemented by a carbohydrate source during periods of exertion at altitude.

8.4.2.5 Nutritional and Hydration Status of Special Forces Soldiers Consuming the Ration Cold Weather or Meal Ready-tr-Eat During a Ten Day Cold Weather Field Training Exercise.

492. Four teams of Special Forces volunteers were divided into two groups to test the Meal Ready-to Eat (MRE) and the Ration Cold Weather (RCW) rations in a field test in a moderately cold environment (16). The MRE group was allowed to select their 10 day food supply from an issue of 4 MREs per day. The RCW group carried the entire ration into the field. Pre and post measures were taken and field data was limited to questionnaire and a daily urine dipstick measure. Both groups lost weight (MRE = 6.9 lbs (3.1 kg); RCW = 5.9 lbs (2.9 kg)) as the average caloric intake was 2733 kcal (11.4 MJ) for the MRE group and 2751 kcal (11.5 MJ) for the RCW group. These caloric intakes were approximately 1000 kcal (4.2 MJ) less than their predicted energy requirements. Both groups showed evidence of dehydration (as indicated by elevated urinary specific gravity) which could have been reduced by better water discipline. The RCW ration consumption led to lower protein, lower salt and higher carbohydrate intakes than the MRE ration. The daily RCW ration (4541 kcal 19.0 MJ)) weighs about half as much as a comparable caloric amount of MRE ration (4 rations = 4892 kcal (20.5 MJ)). There did not appear to be any significant difference in the consumption of the two rations, but the theoretical decrease in water requirements due to lower protein and salt content and the decreased weight make the RCW a better choice for use in cold environments where freezing, water availability and weight are important considerations. The results of this study indicate that although the RCW supported soldier performance in this FTX similar to the MRE, it offered no improvement in reducing weight loss, increasing caloric intake or hydration status compared to the MRE. A future version of the RCW should maintain the present carbohydrate level but reduce the sugar content by reducing the bar/cookie components and include items to encourage fluid consumption.

8.4.2.6 Nutritional Status and Physical and Mental Performance of Special Operations Soldiers Consuming the Ration Lightweight or the Meal Ready-to Eat Military Field Ration During a 30 Day Field Training Exercise.

493. A 2000 kcal (8.4 MJ) lightweight ration (RLW-30) was tested as the sole source of food for 30 continuous days during a Special Forces field training exercise (FTX) in September and October 1986 at Camp Ethen Allen, VT (17). Eighteen Special Forces soldiers were assigned to the RLW-30 group and another 18 were assigned to a calorie adequate control ration (MRE VI). Both groups of soldiers performed similar missions at the same location but were physically separated from each other. A battery of physical and psychological tests was conducted during and after the 30 day FTX. Food and water intakes were recorded daily and nutrition and hydration status were evaluated. Medical examinations were conducted before, during and after the FTX. Soldiers consuming the RLW-30 ration lost an average 11.4 lbs/man (5.2 kg/man) (6.3% of original body weight)

compared to 4.0 lbs/man (1.8 kg/man) (2.2% of original body weight) for the MRE group. The weight loss for the MRE group was provided by body fat loss. The weight loss for the RLW-30 group came from a combination of body fat and lean body mass. Aerobic capacity decreased 10.2% for the MRE group and 14.8% for the RLW-30 group. Isokinetic muscle strength and endurance did not decrease in the MRE group but decreased 3.1 and 7.9% respectively in the RLW-30 group. There were no differences between groups in handgrip strength or PT test performance. Vigilance, mood, morale and cognitive ability were maintained to a similar degree in both groups, but the RLW-30 group completed less voluntary cognitive work and reported significantly more symptoms (weakness, dizziness/lightheadedness and symptoms related to visual, motor and cognitive disturbances). Medical examinations did not reveal serious medical problems and there was no evidence of direct ill effects from the ration. Some members of the RLW-30 group noted trace urinary protein and microscopic hematuria by the dipstick method but follow-up evaluation by urine analysis revealed normal urine. One test subject was removed from the RLW-30 group after 21 days for medical problems that were not directly attributable to the ration. Seventeen out of 18 test subjects were able to complete the 30 day FTX in both groups. Nutrient intakes were adequate to meet Military Dietary Allowances for both groups except for energy and protein in the RLW-30 group. These macronutrients were intentionally reduced in the ration to meet size and weight constraints and reduce the water burden of the ration. The hydration status of both groups was good. The RLW-30 group consumed 4.4 litres of water/man/day compared to 3.4 litres/man/day for the MRE group.

494. The RLW-30 is a compact ration that is palatable and easy to use by the soldier in the field, provided an adequate supply of water is available. It supported physical and mental performance reasonably well in a low stress temperate environment. The results of this study indicate that the RLW-30 ration, if used as a sole source of food for 30 days, can be expected to cause some uncomfortable physical symptoms and a small to moderate decrement in physical performance capacity that should be considered in mission planning. The extended use of the RLW-30 should be restricted to its intended purpose (i.e., special operations with low levels of physical activity in a temperate environment for periods not exceeding 30 days).

8.4.2.7 Field Evaluation of Improved MRE, MRE and MRE IV

495. Previous field tests have demonstrated that early versions of the Meal, Ready- to-Eat (MRE's I-V) are not consumed in sufficient quantity when this ration is fed to troops as their sole source of subsistence. In an effort to improve consumption and consumer acceptance of the ration, a number of changes have been incorporated into more recent versions of the MRE. These modifications are based on the results of previous testing. MRE VII, procured for FY 87, contains 8 oz (227 g) rather than 5 oz (142 g) entrees in 7 of the 12 menus, a fruit flavoured beverage powder added to every menu and a hot sauce added to three of the 12 menus. Feedback from the field and from Major Army Commands as well as efforts to reduce production problems have resulted in further changes leading to the

Improved MRE. This ration contains nine entirely new entrees, including two breakfast entrees, two reformulated entrees, 8 oz (227 g) entree portions in 10 of the 12 menus, wet-pack fruit in place of dehydrated fruit, an oatmeal cookie bar in place of some cakes and cookies, new candies and a hot sauce in four menus.

496. The question arose as to which version of the MRE should be procured for the FY 88 Date of Pack. In this field test [18] three versions of the MRE were compared: MRE IV, MRE VII and the Improved MRE. The central issue addressed by the test was whether the changes to MREs I-V embodied in the MRE VII and Improved MRE are effective in increasing consumption of the ration and lead to a ration that better meets the user's needs.

497. In October/November 1986 an 11 day field test was conducted with troops from the 25th Infantry Division, which compared MRE IV, MRE VII and Improved MRE. Three rifle companies of the 4/87th Battalion served as test subjects, participating in a planned training exercise at the Captain Cook and Pohakuloa Training Areas on the Island of Hawaii. All the troops in each company were fed one version of the MRE as their sole source of food for the duration of the test. Measures of body weight and urine concentration as well as background demographic information were collected prior to the test. During the test, body weight, nutrient intake, water intake and urine concentrations were measured 8 times over the course of the 11 days. Food acceptability ratings were gathered on three test days. On day 11, the troops in each company filled out a detailed questionnaire about their perceptions of the version of the MRE they were fed.

498. In general troops fed the Improved MRE consumed more food, lost a lower percentage of their initial body weight, drank more fluid and found the components of their ration to be more acceptable than troops fed either the MRE VII or MRE IV.

499. In addition, the three ration groups were compared in terms of their hydration status. Hydration status was indexed by the average urine specific gravities and by the incidence of urine specific gravities above 1.030, the standard criterion level above which less than optimal hydration is indicated. These measures showed that troops fed the Improved MRE and MRE VII (both of which contain fruit flavoured beverages) were better able to maintain their hydration than troops fed MRE IV.

500. One observation that bears further examination is that troops found the items in the Improved MRE to highly acceptable yet consumed only 2842 kcal (11.9 MJ) per day. It is possible that the ration developer has achieved as tasty and appealing an operational ration as possible and that further development in consumption will emerge only when we fully understand the environmental and situational factors that affect consumption and incorporate this knowledge into training and field feeding procedures.

8.4.2.8 Effects of an NBC Nutrient Solution on Physiological and Psychological Status During Sustained Activity in the Heat

501. Soldiers involved in nuclear, biological and chemical (NBC) warfare may be encapsulated in protective clothing for up to 24 hours. In that configuration the soldier is in a fasting state unless he can move to a decontamination area to eat. A study (19) to determine if a nutrient solution containing 2.34% carbohydrate and 24.1 mEq sodium per litre (NBC Nutrient Solution) would be more effective than a control solution of coloured and flavoured water in maintaining the physiological and psychological status of a person under thermal conditions that simulated encapsulation.

502. Twelve healthy, young males wearing athletic clothing were exercised at 400 watts in a climatic chamber to produce a sweating rate of 0.5 litres/hour. Each subject was tested on both solutions and the assignment of solutions was counterbalanced. The test subjects were to be tested for a maximum of 24 hours on the NBC Nutrient solution and 24 hours on the control solution; actual endurance times were 17.1 $\pm$ 3.6 (Mean $\pm$ SD) and 16.0 $\pm$ 2.9 hours respectively. Fluid intakes were encouraged and the subjects maintained hydration fairly well.

503. The increase in blood glucose levels and delayed appearance of urinary ketones for subjects drinking the NBC Nutrient solution were noteworthy physiological differences between the two solutions. Water was as effective as the NBC Nutrient solution in maintaining cardiovascular, thermoregulatory, and hydration status. No significant differences were noted in the cognitive, motor performance and vigilance tests. The NBC Nutrient solution significantly lowered self reporting symptoms intensity and improved mood after 6 hours. The NBC Nutrient solution was significantly more acceptable and preferred over the flavoured water; this might alter the results of tests in which subjects are allowed to consume the fluid ad libitum or of tests in field situations in which soldiers don't drink enough. Test data from hours 12-24 were inconclusive because of the reduced numbers of subjects but suggested that the NBC Nutrient solution might affect physiological and psychological performance in studies which are more stressful or of longer duration.

504. The results of this study indicate that water and the NBC Nutrient solution were equally effective in maintaining the hydration and physiological status of exercising subjects under hot, dry conditions for periods of 12 hours and perhaps up to 24 hours. The NBC Nutrient solution was more palatable, lowered symptom intensity and improved mood; cognitive performance was not improved.

8.4.3 Germany

8.4.3.1 Military Physiological Testing of a Nutrient Solution Ingested through an NBC Protective Mask Drinking Tube by Military Personnel in Protective Clothing

505. 15 volunteer candidates, who had been instructed and wore full NBC protection, tested a nutrient solution ingested by a NBC protective mask drinking tube (20). In groups of three, subjects spent 28 hours in a special room where they underwent psychological tests and bicycle ergonometrics. Prior to and subsequent to the tests, they were weighed with and without clothing; and sodium, potassium, cortisol, and creatinine levels determined from spontaneously discharged urine samples. Motivation was increased by incentive payments depending upon performance.

506. Five test subjects prematurely terminated the test for medical or psychological reasons. The remaining 10 test subjects drank an average 1240 ± 533 ml (8.3 ± 3.6 pouches) containing a nutrient solution. The time required to do this was approximately 25 minutes. The value of 282 ± 02 ml for the water balance which was determined on the basis of fluid intake and urine output was slightly positive. By taking into consideration the weight loss, the value of -1840 ± 340 ml for the water balance was significantly negative. The value of -634.3 ± 63.5 and 23.6 for the sodium and potassium balances were negative.

8.4.4 Canada

507. Canada has a somewhat less formal on going programme to evaluate the Individual Meal Packs (IMP). Changes in menus are made annually in order to introduce new food items available on the market, improve the nutritional quality of the meal and eliminate menu items which are less popular. A questionnaire is included within each meal so that continual feedback is provided to evaluate acceptance and popularity. A copy of the current questionnaire is at Annex I.

8.5 EMPIRICAL RESEARCH UNDERTAKEN TO ESTABLISH NUTRITIONAL INTAKE IN GARRISON FEEDING SITUATIONS

508. A number of countries have recently undertaken dietary surveys on various military population groups.

8.5.1 Canada

509. Major Norah H Bennett undertook, as part of a Masters Degree in Nutritional Education, a study at two Canadian Forces bases. This study was to assess nutritional knowledge, nutrient intakes and opinions about nutrition education as well as to develop, test and evaluate a nutrition education programme.

510. Nutrient intakes were measured using a three day food diary and were recorded for the 25 male and 15 female junior ranks. Mean intakes and estimates of true deficiency were calculated from the Food Analysis Programme and the Nutrient Analysis Programme of the Department of Foods and Nutrition at the University of Maitoba. Results which were reported in the Netherlands Military Journal (21) are summarized in Table 8.7

511. Major M.J. Wallace studied 42 experienced servicemen, 24 living in quarters and 18 in private accommodation, in order to contribute towards baseline data on nutrient intakes and activity patterns for the nutrient component of the Canadian Forces Quality Improvement Programme. Nutrient intakes were measured using a 3 day diary and results are summarized in Table 8.7.

8.5.2 Netherlands

512. Mrs Karin F.A.M. Hulshof and Mr R.J. Egger, as part of a study into the nutritional and physical health of military personnel, surveyed 323 men aged 20-55 years randomly selected from the Air Force in the town of Arnheim. These consisted primarily of professional military personnel who eat mainly at home. Using a 24 hour dietary recall, diets were recorded and the mean intake calculated from Dutch Food Composition Tables. Comprehensive results were reported in the Netherlands Military Journal (22) whilst results for the age group 25-29 are summarized in Table 8.7.

8.5.3 United Kingdom

8.5.3.1 Royal Navy

513. Lieutenant Commander David C.C. Alexander undertook, in partial fulfillment for a Masters Degree in Dental Public Health, a nutritional analysis of the food provided in ships of the Royal Navy. Using the Food Account method, data was collected for 14 consecutive days from the ships at sea involving a total complement of 2311 sailors. Data was also collected on the average daily sale of selected products from the ship's canteen. Mean intakes were calculated from British Food Composition Tables and the results are summarized in Table 8.7

8.5.3.2 Army

514. Major John S.A. Edwards surveyed, as part of a Defence Fellowship, a total of 1654 male and female soldiers serving in five military units in the United Kingdom. Using the Food Account method, food issues to the main kitchens were recorded over a 28 day period. Mean nutrient intakes, taking into consideration losses in the preparation and part of the production stages, were calculated from British Food Composition Tables. Results are summarized in Table 8.7.

8.5.4 United States

515. The United States has, for a number of years, had a research programme investigating the nutritional intake derived in garrison feeding. This programme has evaluated a number of scenarios, for example, aboard a ship both before and after implementing a "Fast Food" service system (23): before and after the installation of a "Multi-Restaurant" system (24): and male and female cadets (25).

516. Recently a series of nutritional assessments was undertaken by the U.S. Army Research Institute of Environmental Medicine (26) to evaluate the impact of nutritional initiatives planned to moderate soldiers' sodium, fat and cholesterol intakes and to provide low calorie menu selections. By reference to known portion sizes visual estimates were made of the amounts of food served, returned and therefore consumed at 2 dining facilities, one (Ft Lewis, Washington) operated by military personnel and the other (Ft Riley, Kansas) operated by a contractor. Over a 7 day period this assessment was carried out for 76 personnel and the results are summarized in Table 8.7.

(a) Discussion

517. Results from each country's dietary survey, as already indicated, are summarized in Table 8.7. A direct comparison between these various population groups is not strictly valid for a number of reasons. Results, for example, for the United Kingdom represent the amount of food delivered to each food service location and although allowances have been made for wastage, cooking and processing losses have not at this stage been taken into consideration. These particular results may therefore be overstated especially for those nutrients most sensitive to the rigours of cooking and processing primarily vitamin B1 (Thiamin) and vitamin C. However within these limitations each provides a broad indication of nutritional intake.

(b) Energy and Fat

518. The recommendations for energy are below the RDAs in two countries, above in one and in approximate agreement in another. Exact energy requirements are difficult to quantify and depend on a number of factors as already discussed in Chapter 2. Surplus energy is stored as fat and overconsumption is something to be avoided. Energy consumption within the United Kingdom may well be excessive particularly as the energy intake derived from sources other than the main dining room have not been taken into consideration. Corrective action may be required. Food intake of all countries surveyed exceeded the dietary recommendations of 35% of energy from fat (see Annex III). A high priority, therefore, in garrison feeding, should be to reduce the amount of fat consumed.

Table 8.7 Mean Daily Intakes of Nutrients

		CANADA			NETHERLANDS	UNITED KINGDOM		UNITED STATES		RECOMMENDATIONS
Nutrient	Unit	Male n26	Female n15	Male n42	Male 25 - 29 n466	Navy n2311	Army n1654	Ft Riley n43	Ft Lewis n31	Moderately Active Male soldier
Energy	kcal	2876	1694	2496	2910	3734	3480	3112	3173	3200
	mJ	12.0	7.1	10.4	12.2	15.6	14.6	13.2	13.3	13.4
Protein	g	112	70	100		143	104.4	123	125	100
Fat	g	125	72	108		173	169.5	130	132	-
Carbohydrate	g	283	176	233		427	401.9	367.9	378.1	-
Fibre	g	4.4	3.6							-
Dietary Fibre	g					30	31.2			-
Calcium	mg	1330	893	1016	1025	1377	1009	1335	1752	800 - 1200
Iron	mg	13.6	9.8	13.4	13.2	23.9	18.3	17.7	18.7	10 - 18
Thiamin	mg	1.6	1.07	1.45	1.2	2.18	2.14	2.3	2.2	1.6
Riboflavin	mg	2.74	1.74	2.47	1.9	2.78	2.24	2.5	3.2	1.9
Niacin (NE)	mg	44.5	25.5			31.6	26.7	26.7	26.3	21
Ascorbic Acid	mg	98	102	107	96	129.9	119.9	164	132	60
Vitamin A (RE)	mcg	906	763	2035		2192.9	2268.6	1376	1616	1000
Total Folate	mcg	176	141			259.2	289.2			400
Sugars	g					140	131.9			-
Sodium	mg					4549	5670.8	5668	5020	1100 - 3300
Vitamin D	mcg					7.6	4.8			5 - 10
Cholesterol	mg				430	788	539.4	761	744	-
Percentage of Energy from:										
Fat	%	39	38	38.9	36.9	41.7	43.6	37.8	37.4	35
Protein	%	16	17	16	12.2	15.3	12.0	15.6	15.8	-
Carbohydrate	%	39	42	37	41.0	42.9	43.3	47.3	47.7	50 - 55
Ethanol	%	6	3		10.8					-

(c) Dietary Fibre

519. A direct comparison between fibre consumption is difficult to undertake because of the methods of analysis used. Both surveys in the United Kingdom suggest that the consumption of Dietary Fibre is in line with the Dietary Goals.

(d) Other Nutrients

520. The remaining nutrients, with minor exceptions, are in broad agreement with the Recommended Dietary Allowances and Dietary Goals and only limited corrective action may be required.

8.6 FINAL CONCLUSIONS AND RECOMMENDATIONS

521. The importance of monitoring and evaluating food preferences, food acceptance and the nutritional intake derived from military feeding has long been recognized and a number of countries have had regular programmes underway for some years. The importance of these aspects has recently received further impetus partly because of the increased awareness to consume a healthy balanced diet both in Garrison feeding and out of barracks and partly the need to obtain value for money in all areas of defence spending.

8.6.1 Combat Feeding

522. In the United Kingdom a limited programme was undertaken to assess the consumption of combat rations both under operational and exercise conditions. The results have revealed a number of weaknesses but this has provided the basis for corrective action and the stimulus for further development. Now that it has begun, it should not be allowed to cease here but should be developed to incorporate all NATO armies. The value of joint military cooperation through interoperability is well established and this should be extended to combat rations.

523. The United States has, for a number of years, had a regular programme designed to measure food consumption and soldiers' opinion of combat rations consumed under a variety of environmental and operational conditions. This programme has provided a substantial amount of data and enabled decisions to be made on proven fact rather than ill judged opinion. An excellent example of this is where improvements made to a ration are evaluated prior to a purchase decision involving finances in excess of $ 200M (18). It is proposed that this programme continues into the foreseeable future.

524. It has been agreed that the Hedonic Scale provides a valuable instrument for measuring food preference which in turn is indicative of consumption. It has been further established that food preference and consumption on training exercises are a fair reflection of what is likely to occur in battlefield scenarios. However, actual food consumption data is generally regarded as the most important and reliable component of any ration evaluation programme.

525. The following recommendations are therefore made:

(a) Each member nation introduces a programme of food preference and nutritional evaluation for their own combat feeding systems using whenever possible the methods identified in this report.

(b) The possibility be explored during a major NATO exercise, of exchanging combat rations, monitoring food preference, food acceptance and consumption with a view to standardizing either individual components or complete rations.

8.6.2 Garrison Feeding

526. Monitoring nutritional intake in garrison feeding can be achieved in a number of ways although no method stands out as being superior, each having advantages and disadvantages. Each method provides useful data although these normally show mean values. It is recommended that research be undertaken to explore and develop a methodology capable of presenting and describing dietary data beyond the population mean and estimating true nutrient deficiencies.

527. Which ever method is adopted, it is recommended that countries adhere to and follow through a programme of evaluation in order to ascertain not only what current intake is but also the effects of any intervention strategy which may be introduced. If then through dietary surveys it appears that a deficiency may exist, bio-medical analysis may be necessary.

8.7 REFERENCES

1. R.E. Johnson, R.M. Kark. Feeding Problems in Man as Related to Environment. Quartermaster Food and Container Institute of the Armed Forces. Chicago. p 77. (1947).

2. J. Eindhoven, D.R. Peryam. Measurement of Food Preferences for Combinations. Fd Tech. 13: pp 379-382 (1959).

3. O. Maller, A. Cardello. Ration Acceptance Methods Measuring Likes and Their Consequences. Nederl Milit Geneesk T. 37: pp 91-95 (1984).

4. D.R. Peryam, F.J. Pilgrim. Hedonic Scale Method of Measuring Food Preferences. Fd Tech. 11: pp 9-14 (1957).

5. L.V. Jones et al. Development of a Scale for Measuring Soldiers' Food Preferences. Fd Research. 20: pp 512-520 (1955).

6. The Sensory Evaluation Division of the Institute of Food Technologists. Sensory Evaluation Guide for Testing Food and Beverage Products. Fd Tech. 35: pp 50-59 (1981).

7. L.A. Sather, L.D Calvin. The Effects on Number of Judgements in a Test on Flavour Evaluations for Food Preferences. Fd Tech. 14: pp 613-615, (1960).

8. D.D. Schnakenberg, et al. Validation of a Visual Observation Method for Nutritional Evaluation of Food Service Systems for Military Populations. in Federation Proceedings. Vol 46 (3), p 875. (1987).

9. M.S. Rose, et al. Determination of Nutritional Intakes by a Modified Visual Estimation Method and Computerized Nutritional Analysis for Dietary Assessments of Military Field and Garrison Feeding. US Army Research Institute of Environmental Medicine. Natick, MA. (In preparation).

10. F.J. Pilgrim. The Components of Food Acceptance and Their Measurement. Am J. Cl Nutr. 5: 171-175 (1957).

11. E. Hirsch, et al. The Effects of Prolonged Feeding Meal Ready-to-Eat Operational Rations. US Army Natick Research, Development and Engineering Center Technical Report. TR-85/035. October 1984.

12. D.D. Schnakenberg, et al. Nutritional Evaluation of a New Combat Field Feeding System for the Army. Army Science Conference Proceedings. Vol IV, p 69-80, 17-19 June 1986.

13. Combat Field Feeding System. Force Development Test and Experimentation (CFFS-FDTE). US Army Combat Development Experimentation Center, Ft Ord, CA. and US Army Research Institute of Environmental Medicine, Natick MA. Test Report CDEC-TR-85-006 A,B, and C. January 1986.

14. M.S. Rose, D.E. Carlson. Effects of A Ration Meals on Body Weight During Sustained Operations. US Army Research Institute of Environmental Medicine, Natick, MA. Technical Report T2-87. October 1986.

15. E.W. Askew, et al. Nutrient Intakes and Work Performance of Soldiers During Seven Days of Exercise at 7,200 feet Altitude Consuming the Meal Ready-to-Eat Ration. US Army Research Institute of Environmental Medicine, Natick, MA. Technical Report T3-87. November 1986.

16. D.E. Roberts, et al. Nutritional and Hydration Status of Special Forces Soldiers Consuming the Ration Cold Weather or the Meal Ready-to-Eat Ration during a Ten day Cold Weather Exercise. US Army Research Institute of Environmental Medicine, Natick, MA. Technical Report T8-87. 1987.

17. E.W. Askew, et al. Nutritional Status and Physical and Mental Performance of Special Operations Soldiers Consuming the Ration Lightweight or the Meal Ready-to-Eat Military Field Ration During a 30 Day Field Training Exercise. US Army Research Institute of Environmental Medicine. Natick, MA. Technical Report T7-87. February 1987.

18. R. Popper, et al. Field Evaluation of Improved MRE, MRE VII and MRE IV. US Army Research, Development and Engineering Center, Natick, MA. and US Army Research Institute of Environmental Medicine, Natick, MA. Technical Report Natick/TR-87/027. January 1987.

19. M.S. Rose, et al. Effects of a NBC Nutrient Solution on Physiological and Psychological Status During Sustained Activity in the Heat. US Army Research Institute of Environmental Medicine. Natick, MA. Technical Report T27-87. July 1987.

20 W. von Restorff, et al. Military Physiological Testing of a Nutrient Solution Ingested Through a NBC Protective Mask Drinking Tube by Military Personnel in Protective Clothing. Central Medical Institute of the Federal Armed Forces. Koblenz. (1987).

21. N. Bennett. Nutrition Education for Military Personnel. Nederl Milit Geneesk T. 37: 73-78 (1984).

22. K.F.A.M. Hulshof, R.J. Eggar. Cardiovascular Risk Factors: Results of a Study Among Royal Netherlands Air Force Personnel. Nederl Milit Geneesk T. 37: 61-69 (1984).

23. M.S. Morris, et al. Nutrient Intakes of the Enlisted Personnel Aboard the USS Saratoga Before and After Implementing "Fast Food" to the Food Service System. Letterman Army Institute of Research. San Francisco, CA. Report No 124. May 1982.

24. M.J. Kretsch, et al. Nutritional Status Assessment of Marines Before and After the Installation of the "Multi-Restaurant" Food Service System at the Twentynine Palms Marine Corps Base California. Letterman Army Institute of Research. San Francisco, CA. Report No 192. December 1984.

25. M.J. Kretsch, et al. Nutrient Intake Evaluation of Male and Female Cadets at the United States Military Academy, West Point, New York. Letterman Army Institute of Research. San Franscico, CA. Report No 218. April 1986.

26. E.G. Szeto, et al. A Comparison of Nutrient Intakes Between A Ft Riley Contractor Operated and A Ft Lewis Military Operated Garrison Facility. US Army Research Institute of Environmental Medicine. Natick, MA. Technical Report T 2-88. October 1987.

CHAPTER 9

NUTRITION EDUCATION: IMPLEMENTATION OF DIETARY GOALS

9.1 INTRODUCTION

528. There is no doubt that nutritional status plays a key role in the state of health of the individual and thereby is a factor influencing the operational readiness and capability of a military force. Van der Beek and co-workers (1) demonstrated that a vitamin B1, B2, and C deficient diet had a dramatic negative influence on physical performance. Brown and co-workers (2) studied the relationship between aerobic fitness and cardiovascular risk factors in 1595 Canadian servicemen and found that the proportion of individuals and their mean values for skinfold thickness, serum cholesterol and serum triglycerides were less for the group in the superior fitness categories. There has been an increasing awareness of the link between dietary factors in Western countries and the major chronic diseases which kill or debilitate the larger portion of our populations. These diseases which include heart disease, some cancers, obesity, hypertension, diabetes, etc, result in loss of life, loss of work time, and decreased productivity of highly trained individuals who are at the peak of their career. Intervention is needed to reduce the risk of their occurrence and to ensure that service personnel are capable of meeting physical performance demands during situations requiring operational readiness.

9.2 WHAT ARE DIETARY GOALS ?

529. Many countries have developed nutrition recommendations. Nutrition recommendations act as guidelines in providing an overall philosophy for integrating all aspects of nutritional health. They provide the framework around which a preventive nutrition education programme is developed and the specific areas toward which the program will be targeted. At the first meeting of RSG-8 in May 1982, dietary guidelines (Annex III) were adopted and are similar to most national or military nutrition goals. It was recognized by RSG-8 that there was a need for further research prior to providing specific guidance on saturated and polyunsaturated fats. Table 1 (Annex IV) provides a summary of nutrition recommendations for selected NATO countries. Generally, there is consensus to emphasize variety in food choice; decrease intake of fat, simple sugars, salt and alcohol consumption; increase intake of whole grains, fruits, vegetables, and fibre; and maintain energy balance to avoid obesity.

530. To be meaningful, goals are based on needs and assessment of the population in question. As a military population is a subset of a larger national population, nutritional goals are best formulated in concert with the country's national nutrition policy and concerned professional organizations. This will ensure that goals are meaningful, appropriate, and conflicting information to the target population will be minimized.

9.3 WHAT IS NUTRITION EDUCATION AND IS IT EFFECTIVE ?

531. Johnson and Johnson (3) define the process of nutrition education as the teaching of validated, correct nutrition knowledge in ways that promote the development and maintenance of positive attitudes toward, and actual behavioural habits of, eating nutritious food (within budgetary and cultural constraints) that contribute to the maintenance of personal health, well-being and productivity. The mere acquisition of nutrition knowledge does not necessarily lead to wise food choice but lack of factual nutrition knowledge will preclude wise food choice from being made.

532. The success of nutrition education has often been questioned and the relationship of nutrition knowledge, attitudes about nutrition and nutrition behaviour have long been the subject of controversy. Much research in nutrition education has been devoted to examining these relationships and attempting to prove they exist. In an extensive meta-analysis of virtually all published and unpublished nutrition education programmes, Johnson and Johnson (3) reported that nutrition education resulted in a marked increase in knowledge, some increase in positive attitudes toward eating nutritiously, and constructive changes in participants' patterns of food consumption. Furthermore, the meta-analysis clearly demonstrated statistically significant relationships between nutrition knowledge and behaviour and between nutrition attitudes and behaviour. Nutrition education research conclusively shows that nutrition education is effective in meeting its goals and objectives. Therefore, the question at this time is not whether nutrition education is successful, because we now know it is. Rather, the questions we should be asking are:

(a) Who are we going to deliver the programme to?

(b) What is the content of the programme going to be?

(c) What are the best means or vehicles to deliver the programme?

9.4 THE TARGET POPULATION AND PROGRAMME CONTENT

533. The target population is determined by asking the questions "Whose behaviour do we want to change and why do we want to change it" ? Essentially, it is based on the observation that a noticeable or significant proportion of a population has a disease or condition which can be prevented or ameliorated by change in nutrition related behaviour. There are many examples in our military populations. A large proportion of service personnel are overweight. This is particularly evident in those jobs which are sedentary such as on ships or at static units. In the Canadian Forces, it has been observed that there is significant weight gain after personnel leave the rigorous physical activity during basic training and move into more sedentary phases of language and trades training (4). Heart disease is a concern in the Canadian Forces as well as the Canadian population in general. Nutrition education has therefore been directed in these areas.

534. Because most countries have adopted dietary guidelines which promote health and address those issues of poor nutritional practice by the population of that country, it is a fair assumption to make that those same principles and observations apply to the military of that country as the military is merely a subset of the larger population. A nutrition issue which is observed as being a problem within the country, such as a high frequency of hyperlipidemia, will also be manifest as a problem within the military.

535. The content of programmes would normally fall within the framework stated by the Nutrition Recommendation (Guidelines). Nutrition Recommendations provide the guidelines for good nutritional health and their very purpose is to address those areas of poor nutritional practice. If nutrition education is to be effective, it must address issues that are not only relevant to the target population, but it must also meet the interests and needs of the target population. For example, nutrition programmes directed toward weight control are relevant to ships but are probably not very relevant to infantry battalions comprised of young, physically active soldiers who do not generally have weight problems. An attempt to deliver a programme that is not relevant would very likely deter subjects from being receptive to future nutrition intervention in other areas that may be relevant and necessary for their health.

536. It is important to direct programmes towards perceived interests and needs of the target population. For example, giving young recruits nutrition information in the hopes of preventing overweight and obesity is best based on their interests in fitness, developing a good physique and presenting an attractive appearance to the other sex. Linking such a nutrition programme to good health, a longer life or prevention of heart disease simply does not address their immediate interests and needs and will likely not be successful.

537. Nutrition information is best presented in a positive, constructive manner in which small, reasonable changes are requested. For example, a programme which directs people not to eat deep fried foods is unreasonable. Rather, it should ask people to reduce the quantity and/or numbers of servings of deep fried foods eaten. People receive information in a more positive manner if there is no "moralizing" or "parenting" by using words such as "should".

9.5 MAXIMIZING SUCCESS IN DELIVERY OF NUTRITION EDUCATION

538. Within the context of the military, there are several factors which can be capitalized upon in order to increase the probability of Successfully changing nutrition knowledge, attitudes and behaviour:

539. The norms and values of the reference group to which one belongs, aspires to belong and with which one identifies, determines the attitudes and behaviours of the individuals comprising the group. It is easier to change behaviour and attitudes about nutrition by changing group norms and values (3).

540. Social models which are visible and credible and demonstrate the recommended attitude and behaviour, are powerful influences (3). In the military context, leaders who endorse, promote and support programmes can greatly influence their subordinates' behaviour.

541. Information that is presented through "face-to-face" interactions and in a manner that is "vivid" is more effective than impersonal information or information presented through statistical summaries. Instructional strategies that are based on student participation and involvement are more successful at teaching than traditional classroom settings. The acquisition of conceptual frameworks and general principles as well as specific attitudes and behavioural intentions can be more predictive of food consumption patterns than learning isolated facts and general attitudes (3).

542. Although findings are not consistent, it is generally felt that fear appeals that emphasize disease and death may be more effective than those that emphasize improved health (3). Gussow (5) recommended that nutrition education programmes focus on the relationship of diet to disease. Rosentock (6) hypothesized that preventive health behaviour will not take place in the absence of symptoms unless the following conditions are satisfied:

(i) The individual must feel personally susceptible to the condition and possible occurrence of the condition must be viewed as having serious personal consequences.

(ii) The individual must feel that the preventive action is feasible and appropriate and would reduce perceived susceptibility or severity of the condition. There must be no psychological barriers to the action.

(iii) A cue or stimulus must occur to trigger the response.

543. Nutrition education linking diet and disease will serve to make the individual feel susceptible to disease and provide the cue or trigger to take action.

544. Nutrition education must not be simply the transmission and storage of information. It must be related to specific actions and state the specific steps that are necessary for behaviour change. The theoretical basis of the Stanford Three Community Study was based on this same concept of "action structures" (7).

545. Several researchers have recognized the importance of providing information where people are confronted with food choices. Glanz and Seewald-Klein (8) stated that such programmes increase opportunities to learn to make healthy food choices and reduce barriers to behaviour change. Additionally, they impose minimum time and effort on workers and can reach large audiences on a continual basis. Glanz (9) further recommended that we should capitalize on situations where people make life changes in

conjunction with making nutrition decisions such as providing nutrition education in college dormitory cafeterias.

546. For obvious reasons, it is more desirable to prevent disease, rather than wait for its occurrence and treat it. In the Canadian Forces, weight gain starts to occur in the more sedentary phases of training after completion of basic training. Also, members who live in quarters and eat in the mess hall weigh more than those that live out (10). Information on both weight control and good eating habits, is important at the very start of the member's career. There is the added advantage of having them as a "captive audience".

547. Implicit within the concept of communication theory is the notion of frequent repetition of the message in order to emphasize the subject and provide a frequent and continuous cue. As well, there is increased probability of success if the requested change is small.

548. It is important that information given be accurate and valid. There is a great deal of faddism and many self-proclaimed experts in nutrition who have the potential of causing great harm and confusion. A positive tone in presenting information will increase the probability that action will be taken.

549. In order to make desired eating behaviour easier, it is necessary to minimize environmental barriers. That is, it is imperative that our food services systems prepare and serve the foods which our nutrition education programme tells our target populations to eat. Jacobs (11) reported that a single lunch can be decreased by as much as 30% by having smaller portions available. The United Sates Department of Defence retrained all of its cooks in order to teach them the best foods and preparation techniques to meet nutritional goals. Dalton and co-workers (12) found that the sensory aspects of food were the dominant determinants in choice of food. If we want people to change their choice of food, it must taste good.

550. Legislation is an effective means of bringing about changes in behaviour. For example, both Canada an the US have a policy on obesity. Previously, the Danish Navy had unlimited resources to spend on food. Now, the menu is calculated on a nutritional basis with a maximum of 3600 calories and money is allotted to cover the cost of the menu.

551. Those conducting the programme may have a certain amount of opposition if their attitude is not positive or their workload increases. It is therefore, recommended that delivery be simplified as much as possible.

9.6 DELIVERY OF NUTRITION EDUCATION PROGRAMMES IN THE MILITARY

552. Nutrition intervention takes both personnel and financial resources. The nature and extent of the programme implemented will depend upon the resources available. Some interventions can be made at no cost and other interventions can be made at minimal cost.

553. It is necessary to study and analyze the entire setting of the programme carefully in order to capitalize on all opportunities and to ensure that everything in the total environment is supportive of promoting the desired change. For example if we are encouraging diners to select fruit instead of pastries for dessert, then it is critical that a good selection of attractive fruit be available.

554. An example of a successful military nutrition intervention programme is the Canadian Forces Nutrition Month campaign. It is developed annually and conducted at the same time as the National Nutrition Month campaign. It uses the same theme as the national programme, with minor adaptations for the military. Resource materials used in the campaign include table tents, posters and pamphlets developed by the Canadian Forces, the Canadian Dietetic Association, industry and marketing boards. Cooks are given new recipes to feature in dining halls. Resource materials are compiled centrally and mailed in bulk to all units, where they are displayed. Units are given precise instructions concerning what they are required to do. By implementing the programme in this manner, all units participate because the work is done for them. Opposition and non-participation is thereby minimized. The US Army has recently initiated a Nutrition Month programme similar to the Canadian Forces. The United Kingdom is currently investigating the inclusion of a nutrition education programme within their training programme. It is assumed that military forces must work within resource restrictions, therefore the following interventions are ones which require minimal resources and are either used or will be used in the future in the Canadian Forces.

9.6.1 Changing the Environment

555. Take appropriate action to promote and make available more nutritious food choices, including low fat milk, fruit, whole grain breads and cereals, raw vegetables, etc.

556. Change recipes to use less fat, less sugar and increase whole grains. Change the emphasis in menu planning from fried foods, to more broiled and baked foods. Use low fat milk in soups and sauces. Serve smaller portions, especially of desserts and meats.

557. Teach cooks principles of nutrition and change course training material so that sound nutritional principles are incorporated into their training including (1) and (2) above and food preparation techniques which optimize vitamin content such as reducing cooking and servicing time.

558. Implement programmes with available resources including physicians, nurses, dietitians, etc., to teach nutrition and fitness to wives as well as husbands, as wives are usually the ones preparing meals and thus determining what their husbands eat.

9.6.2 Educating the Client

559. Incorporate a film about nutrition and weight control into basic training. Films are entertaining and colourful, and will make a vivid visual impact. Promote short syndicate discussions after the film on how to incorporate good eating habits and weight control into military life.

560. Make nutrition information available at point-of-purchase. The US military have 1500 kcal/day menus available in their dining facilities. The CF have successfully used "table tents" which contain nutrition information and are either self-standing or inserted in a plastic menu holder. Nutrition information presented in this setting will hopefully generate discussion within the peer group and instigate changes in the behaviour and attitude of the peer group.

561. Obtain posters and pamphlets from manufacturers of food items, agricultural producers, marketing boards, other government departments, and professional organizations. They are usually free or can be purchased for a nominal charge. In some cases, it is possible to avoid the cost of developing the teaching instrument by borrowing the printing plates or arranging to pay for the cost of over-runs.

562. Take advantage of outside peer review. Consultation with nutrition educators in government departments, professional organizations and academia are available and ensure that programmes are meaningful, appropriate and are commensurate with current research and national nutrition policy.

563. Use available media at military units to promote good nutrition. For example, Canada has a newspaper at each base which has an added advantage of reaching wives and other family members. Information can be printed in routine orders or tapes can be made and played over military radio stations.

564. Make films and videos about nutrition available. For example, the CF previews and places nutrition films and videos in regional libraries. Bases are notified of their availability so that they can be shown at those locations that are interested.

9.7 EVALUATION

565. Evaluation is an essential component of any nutrition education programme in order to measure impact and justify the use of resources. Evaluation can be complex, expensive and time consuming, depending upon the level of sophistication. The method of evaluation used and the indicators to be measured or assessed are best incorporated into the programme during the planning phase.

566. An example of a simple, inexpensive form of evaluation is that used to assess the Canadian Forces Nutrition Month programme. A questionnaire is sent to each unit coordinator asking their opinion about

the popularity and effectiveness of the different education materials. Unit coordinators are also asked for their suggestions and comments. The programme developed each year incorporates the comments received from past years. Analyses of comments have been successfully used to convince "doubters" about the impact of the programme. Other simple means of evaluation may include a nutrition knowledge test, tabulating selection of food items, and/or checking types of food served or procured pretest and post test.

9.8 WEIGHT CONTROL PROGRAMMES

567. Both the US and Canadian Forces have developed a policy concerning military members who are overweight. The US policy on weight control and subsequent programme for diet counselling was presented at a previous RSG 8 meeting and was reported in the Journal of the American Dietetic Association (13). Weight control is incorporated in the US Army Health Promotion Programme called "Fit to Win". Canada has developed a similar policy. Both US and Canada refer those identified as obese for diet counselling. Chapter 5 states the maximum allowable body fat standards for the US and Canada. A comprehensive behavioural weight control programme similar to the Canadian Forces smoking cessation programme called "Butt Out" is being developed for Canadian Forces wide application. It is expected to be completed and implemented soon.

568. What is important is to prevent the onset of obesity. This should not be a difficult task in a military force. Recruits are required to meet certain standards to join the military, therefore overweight recruits can be screened out. If resources are allocated to educate recruits concerning obesity during the start of their military career, risk of obesity is decreased. Regular screening on a yearly basis through fitness testing or medical evaluation will discourage obesity and identify those that require additional education or disciplinary action. We know that cancer can be more successfully treated than obesity, so it is imperative to concentrate resources towards obesity prevention.

9.9 CLOSING THOUGHTS

569. Consumers are continually barraged with nutrition information and misinformation. It is truly a complex jungle for the uninformed. Our responsibility is two-fold. We can make the environment conducive to wise selection of foods by making healthy food choices available and by taking action to minimize the use of fat, sugar, refined flours and salt in our food preparation and service. We can also arm our military members with information so that they are better informed to make healthy food choices. Although it sounds like an overwhelming task, it need not be. "The only way to eat an elephant is one bite at a time". By following this principle, many small changes that are relatively easy and inexpensive can be made.

570. What we eat is governed by complex social, cultural and economic Values. It is unreasonable to expect radical change in people overnight, especially when we are encouraging other major life style changes in the areas of smoking, drinking and exercise. It is important to be patient, encouraging and positive in our approach. Our expectations are often very high. It is important to remember that a company considers an advertising campaign successful if it persuades only a small fraction of the population to use its product. We must learn to view a small change in nutrition behaviour as a success, yet continue to look for other ways to make greater success.

9.10 SUMMARY AND CONCLUSIONS

571. Nutrition is a critical factor in the health and physical performance of an individual and thereby affects the operational readiness of a military force. Nutrition education is an effective means of improving nutrition related behaviour and has been successfully used in some NATO forces. Nutrition education must address relevant issues and be appropriate to the target population. It is important that all aspects of the environment are supportive of the nutrition education programme. There are many strategies which can be employed to maximize success of nutrition education in the military setting.

9.11 REFERENCES

1. Van der Beek, E.J., W. Van Dokkum, and J. Schrijver. 1984. Marginal vitamin intake and physical performance in man: possible implications for military personnel Nederl Milit Geneesk 37:47.

2. Brown, T.E., W.S. Myles, and C.L. Allen. 1979. The Relationship Between Aerobic Fitness and Cardiovascular Risk Factors in the Canadian Forces. DCIEM Technical Report No. 79X11, Department of National Defence, Canada.

3. Johnson, D.W. and R.T. Johnson. 1985. Nutrition Education: a model for effectiveness, a synthesis of research. J. Nutr. Ed. 17:S1.

4. Mateau, J.M. 1978. An assessment of the nutritional status and of the dietary patterns of young French Speaking Canadian Servicemen. MSc thesis. University of Guelph, Guelph, Ontario.

5. Gusson, J.P. 1981. What is nutrition education? Proceedings from the conference Stimulating Nutritional Awareness and Action in Military Populations, ed. Maller, O., US Army Natick Research and Development Laboratories, Natick, Massachusetts. pp. 126-131.

6. Rosenstock, I.M. 1966. Why people use health services. Milbank Memorial Quarterly. 44:94.

7. Stern, M.P., J.W. Farguhar, N. Maccoby, and S.H. Russell. 1976. Results of a two-year health education campaign on dietary behaviour. Circulation. 54:826.

8. Glanz, K. and T. Seeward-Klein. 1986. Nutrition at the worksite: an overview. J. Nutr. Ed. 18:S1.

9. Glanz, K. 1981. Social psychological perspective and applications to nutrition education. J. Nutr. Ed. 13:S66.

10. Wallace, M.J. 1980. Nutrient intakes and activity patterns of forty-two Canadian servicemen, thirty-five to forty-five years old. M.Sc. thesis, University of Guelph, Guelph, Ontario.

11. Jacobs, H. 1978. National Ferment in Dietary Goals: Challenge and Opportunities for the Defence Department's Food Program. Activities Report, Research and Development Associates, 30, No.1, 69-85.

12. Dalton, S.S., R.A. Linke, and M.D. Simko. 1986. Worksite food choices: an investigation of intended and actual selection. J. Nutr. Ed. 18:182.

13. Rinke, W.J., J.K. Hertzberger, and F.J. Erdtmann. 1985. The Army weight control program: a comprehensive mandated approach to weight control. J. Am. Dietet. Assoc. 85:1429.

14. Russ, C.S. and R.L. Atkinson. 1985. Comments on the Army weight control program: a critical view. J. Am. Dietet. Assoc. 85:1435.

CHAPTER 10

SUMMARY AND RECOMMENDATIONS

10.1 CHAPTER 2 NUTRIENT REQUIREMENTS AND RECOMMENDATIONS FOR MILITARY PERSONNEL

10.1.1 Summary

572. Nutrient requirements, including water, and recommended dietary intakes for military personnel are, by their very nature, an imprecise calculation especially when applied to individuals. However, data and recommendations for military population groups were reviewed, assembled and are summarized in this chapter. Modifications will need to be made, in due course, as additional research data becomes available. This may result from civilian research or research conducted under the auspices of NATO.

573. Most NATO armed forces, in formulating recommendations, generally follow their own country's guidelines with adjustments for increased levels of physical activity. This chapter contains data on the daily energy requirements for different activities (Table 2.4) and water requirements for different activity levels at different air temperatures (Table 2.7).

574. There is scientific basis for adjusting the food supply for military personnel operating in hot, cold and high altitude environments and the adjustments were described in Tables 2.2 and 2.3. The current recommended intakes of protein, vitamins and minerals for military personnel of the RSG-8 member nations were summarized in Table 2.9. The RSG-8 reviewed and provided technical input for agreed nutritional guidelines for survival, emergency and combat rations as described in NATO STANAG 2937.

10.1.2 Recommendations

575. The recommended dietary intakes presented in this chapter are based upon the information currently available and should be adopted by all NATO nations in the monitoring and evaluation of protein, vitamin and mineral intakes of military personnel.

576. Nutritional strategies to enhance military performance are a relatively new concept and covered in more detail elsewhere in this report. Dedicated research in this area will be required if nutritional status is to contribute towards the health and performance of NATO military personnel.

577. Adjustments of the food supply, in particular energy and carbohydrate, should be made for military personnel operating in hot, cold and high altitude environments.

578. The fact that water requirements are increased by vigorous physical activity and elevated environmental temperatures should be considered in logistical planning of the water supply.

10.2 CHAPTER 3 NUTRITION AND OPTIMUM PHYSICAL PERFORMANCE

10.2.1 Summary

579. The physical performance demands of military personnel range widely depending on a number of factors including individual trade, mission and environmental factors. The use of nutritional strategies to optimize performance is therefore of direct military interest. Current knowledge in this area, as affecting the military population, was considered and evaluated in this chapter. When the intramuscular stores of carbohydrate, in the form of glycogen, are depleted, subsequent exercise performance is impaired. There is direct evidence that muscle glycogen stores of military personnel are markedly depleted at the end of exhaustive combat field trials. There is experimental evidence that the consumption of >450 g of carbohydrate per day is required to facilitate glycogen resynthesis. There is limited experimental evidence that metabolic adaptation to a calorie dense, fat rich, i.e. carbohydrate poor diet may be possible although the time course and extent of adaptation must be clarified before such a diet can be applied in a military setting.

580. There is no consistent evidence to suggest that the capacity to perform physical exercise would be enhanced by the addition of micronutrients in excess of known requirements. There is some limited data to suggest that the ingestion of the amino acid tryptophan may be beneficial in increasing sleep time and avoiding subsequent performance impairments of personnel transported across time zones. The current data base on the effects of dietary manipulation on mental performance is meager at best.

581. Calorie restriction causing gradual weight loss of up to about 10% will not cause drastic performance deficits and therefore calorie restricted rations are feasible for selected short duration military operations where reduced food weight and volume would be advantageous.

582. The environmental stress of heat or altitude causes an anorexia which can result in insufficient energy and/or carbohydrate intake to maintain optimal physical performance. Cold environments, are usually associated with an increased energy consumption, probably because of the increased caloric cost of working in protective clothing and with specialized equipment. The implications of most environmental stresses are that the relative physiological demands of a given task are increased. In all likelihood the energy cost and the dependence on carbohydrates for that energy are also increased.

10.2.2 Recommendations

583. A carbohydrate intake of at least 450 g per day is recommended to facilitate muscle glycogen resynthesis of personnel engaged in sustained exhaustive physical activity.

584. Further research is needed to develop and evaluate nutritional strategies on nutrient supplements to maintain optimal performance of mental or military specific tasks during environmental or operational stress.

585. Certain operational scenarios (i.e. long range patrols without resupply) may require deviations from accepted nutritional guidelines. Such deviations should not extend beyond 14 days until such time as research is carried out to document the possible performance and health implications.

586. Research should be undertaken to evaluate the effects of ingesting calorie dense (i.e. > 60% fat/calorie) diets for several weeks, the time course of metabolic adaptation, and the implications for physical and mental performance as well as health.

10.3 CHAPTER 4 NUTRITION AND CORONARY HEART DISEASE RISK FACTORS IN THE MILITARY POPULATION

10.3.1 Summary

587. The relationship between diet and coronary heart disease (CHD) was reviewed in this chapter and the relative risk of CHD seems to be similar in civilian and military populations. Serum total cholesterol, HDL cholesterol and the ratio total/HDL cholesterol have been established as predictive indicators of CHD risk. Excessive consumption of total fat, in particular, saturated fat and to a lesser extent, dietary cholesterol, has been shown epidemiologically and clinically to be positively associated with increased CHD risk factors. Clinical trials have indicated that dietary intervention (reduced fat, total fat and cholesterol intakes) can reduce CHD risk factors.

10.3.2 Recommendations

588. In order to identify those individuals at increased risk from coronary heart disease, periodic blood lipid tests (cholesterol, high and low density lipoprotein) should be carried out and appropriate intervention, including nutritional counselling, should be administered to those at increased risk.

10.4 CHAPTER 5 BODY COMPOSITION: MEASUREMENT AND ITS RELATION TO HEALTH AND PHYSICAL PERFORMANCE OF MILITARY PERSONNEL

10.4.1 Summary

589. Excess body fat contributes to decreased physical performance of military personnel and is associated with increased health risks. Although there are numerous methods available to assess body fat and these are reviewed in this chapter, they are of varying accuracy and only a few methods (height/weight indices, circumferences and skinfolds) are feasible for large groups of military personnel. The Durnin skinfold method has been applied in research studies of large numbers of UK, NL, US and CA male and female military personnel and these data are summarized in this chapter. However, there is no agreed single method for measuring body composition among the member nations and only the US and Canada have established body composition standards in the implementation of the weight control programmes.

10.4.2 Recommendations

590. Consideration should be given to developing a NATO standard to define overweight and obesity.

591. For applications in a military setting, body composition methods involving weight-height indices, skinfolds or circumferences are recommended.

10.5 CHAPTER 6 ALIMENTATION OF MILITARY CAUSALITIES

10.5.1 Summary

592. Depending on the extent of the injury and subsequent surgery, wounded persons present a high catabolic state requiring aggressive nutritional support to speed recovery. Continued scientific and technological improvements in the quality of proper nutrition of injured/wounded personnel have resulted in major improvements in patient care. Examples of alimentation programmes involving oral, tube or parenteral feeding are described in this chapter.

10.5.2 Recommendations

593. Alimentation programmes involving oral, tube or parenteral feeding should be used to provide nutritional support and speed recovery of military casualties.

594. Further research is needed to define the optimal support for traumatized casualties during wartime.

10.6 CHAPTER 7 RATIONS OF SELECTED NATO COUNTRIES - PURPOSE AND COMPOSITION

10.6.1 Summary

595. All NATO countries participating in RSG-8 make use of packed rations as part of their overall feeding philosophies. The purpose and nutritional composition of survival, emergency and combat rations of each member country are described and summarized in this chapter. These rations currently tend to be diverse in their content, design and to some extent their nutritional composition. Several member countries have made, or are in the process of making, changes to their rations to improve acceptability and lower the fat content to comply with agreed nutritional guidelines of NATO STANAG 2937.

10.6.1 Recommendations

596. The nutritional content of the survival, emergency and combat rations of all member nations should be adjusted as required to meet the nutritional guidelines provided in NATO STANAG 2937.

597. All member nations should determine the nutrient composition, to include vitamins and minerals, of their packed rations.

10.7 CHAPTER 8 GARRISON AND COMBAT FEEDING - OPTIMIZING AND EVALUATING CONSUMPTION

10.7.1 Summary

598. The ultimate objective in military feeding is to provide the soldier with a healthy balanced diet, to stated nutritional criteria, which is of maximum acceptability and within the constraints of cost and available logistics. Monitoring the success of these objectives is likewise essential. This chapter provides a detailed description of techniques which have been used by various member countries to measure food preference, food acceptance and food and nutrient intakes. The results of combat ration trials and garrison feeding studies conducted by member nations since the formation of RSG-8 are also summarized and evaluated in this Chapter. The results of the ration trials have demonstrated that poor acceptability of certain items leads to inadequate energy consumption and body weight loss. Two studies have been conducted to evaluate the possible beneficial effects of a nutrient solution (compared to water alone) to maintain performance of personnel wearing NBC protective clothing for extended (6-24 hr) periods. The results to date have been inconclusive. In general, the fat intakes at garrison situations, in all countries studied, exceed the recommended level of not more than 35% of calories from fat sources.

10.7.2 Recommendations

599. Each nation should introduce a programme of food acceptance and nutritional evaluation of their own packed rations or combat feeding systems using, where possible, the methods identified in this report.

600. The possibility should be explored, during a major NATO exercise, of exchanging combat rations, monitoring food acceptance and nutritional intake with a view to further standardizing or increasing the interoperability of either individual components or complete rations.

601. There is a priority requirement to conduct further research on the possible beneficial effects of a nutrient solution (compared to water alone) to maintain performance of personnel wearing NBC protective clothing for extended (6-24 hr) periods.

602. Each member nation should introduce a programme to ascertain the current dietary intake in Garrison dining facilities. Particular emphasis should be placed on monitoring fat, saturated fat, cholesterol and salt intakes.

10.8 CHAPTER 9 NUTRITION EDUCATION: IMPLEMENTATION OF DIETARY GOALS

10.9.1 Summary

603. Nutrition education is a critical factor in the health and physical performance of an individual and therefore affects the operational readiness of a military force. Nutrition education is an effective measure of improving nutrition related behaviour. Examples of nutrition education programmes and materials currently being used in the CA, UK and US are described in this chapter. The importance of modifying the menus, changing the recipes and training the cooks as well as educating the diners in good nutritional habits is also discussed. There have been no objective studies to evaluate the effectiveness of the nutrition education programmes in a military situation.

10.9.2 Recommendations

604. Each member country should consider implementation of nutrition education and nutrition intervention programmes to promote health and operational readiness. The programmes should include menu modification, recipe changes, training the cooks as well as educating the diners in good nutritional habits.

605. Intervention programmes should be tailored to national problems and should include an evaluation component to determine cost effectiveness.

EXAMPLES OF QUESTIONNAIRES USED BY COUNTRIES
PARTICIPATING IN RSG-8 ACTIVITIES

CANADA

18970-105 (D Food S 2-3)

INDIVIDUAL MEAL PACK (IMP) SURVEY

This survey is to assist us in improving IMP menus. As users of the IMP, your likes, dislikes and comments will be considered in planning future menus.

Food items have been divided into two categories: breakfasts and lunches/suppers. There is a questionnaire for each category. For each pouch menu item listed, please indicate whether you like, find satisfactory, or dislike this item. If you dislike an item, tell us how it can be improved.

Please answer the other questions asked. There is space for your comments at the end of each category.

The following is an example:

	Dislike	Satisfactory	Like
1. Peaches		X	
2. Pears	X		

Remember your comments will be considered in planning future IMP menus.

IMP SURVEY

LUNCHES AND SUPPERS

	DISLIKE	SATISFACTORY	LIKE
Beef/Vegetable Stew			
Turkey/Vegetable Stew			
Scalopped Potatoes/Ham			
Shepherd's Pie			
Beef Ravioli			
Chile Con Carne			
Salisbury Steak Dinner			
Pork Cutlet/Tomato Sauce			

	DISLIKE	SATISFACTORY	LIKE
Meatballs in Gravy			
Swiss Steak			
Turkey Schnitzel/Gravy			
Sweet n'Sour Pork			
Chop Suey			
Instant Mashed Potatoes			
Instant Dressing Mix			
Plain Rice			
Spanish Rice			

Are there any other items that you would like to see in the IMP? ____________________

Are there any items in the lunches or suppers which you don't eat? (eg, tea, soup, jam etc)? ____________________

IMP SURVEY

BREAKFASTS

	DISLIKE	SATISFACTORY	LIKE
Ham Omelette			
Wieners & Beans			
Sausage & Hash Browns			
Corned Beef Hash			

Is there anything in the breakfast pack that you never eat? (eg, juice crystals, ugar, coffee, jam etc).

Is there any other items that you would like to see included? ____________________

Additional comments - ____________________

UNITED STATES

14

DAY 3

MRE RATION CONSUMPTION

CIRCLE THE NUMBER THAT INDICATES HOW MUCH OF EACH ITEM YOU ATE TODAY. THE TOTAL AMOUNT OF EACH ITEM IS SHOWN IN PARENTHESES IN BAR OR PACKAGE (PKT) UNITS. IF YOU EAT AN AMOUNT THAT IS NOT LISTED, WRITE IT ON THE LINE TO THE RIGHT. FOR EXAMPLE: IF YOU EAT 2 CHICKEN STEW BARS, CIRCLE 2. IF YOU EAT 2½ BARS, WRITE IN 2½. IF YOU EAT 5 BARS, WRITE IN 5.

ADDED WATER

PLEASE LIST THE AMOUNT OF WATER YOU ADDED TO EACH FOOD OR BEVERAGE ITEM. WRITE IN "0" IF YOU DID NOT ADD WATER TO A FOOD YOU ATE.

15

DAY 3

RATING OF FOOD

PLEASE CIRCLE THE NUMBERS THAT INDICATE HOW MUCH YOU LIKED OR DISLIKED THE RATION ITEM THAT YOU ATE TODAY.

REASONS FOR NOT EATING/FINISHING

PLEASE WRITE IN THE NUMBERS OF THE PRIMARY REASON THAT YOU DIDN'T FINISH AN ITEM OR DID NOT EAT THE ITEM AT ALL. IF YOUR PRIMARY REASON IS NOT LISTED, WRITE IT IN.

1 SPILLED	9 UNABLE TO HEAT
2 LEFT BEHIND	10 NOT ENOUGH WATER
3 FEEL FULL	11 UNFAMILIAR/STRANGE FOOD
4 TASTED BAD	12 SMELLED BAD
5 DIETING	13 TOO SALTY
6 LOOKED BAD	14 SAVED FOR LATER MEAL
7 TOO BLAND	15 NOT ENOUGH TIME
8 TRADED	16 TOO MUCH TROUBLE

FOOD ITEM	CODE	AMOUNT CONSUMED (BY PACKAGE)					WATER (IN CANTEEN CUPS) (1/4, 1/2, 3/4, 1, ETC.)	DISLIKE EXTREMELY	DISLIKE VERY MUCH	DISLIKE MODERATELY	DISLIKE SLIGHTLY	NEITHER LIKE/DISLIKE	LIKE SLIGHTLY	LIKE MODERATELY	LIKE VERY MUCH	LIKE EXTREMELY	DID NOT EAT	DID NOT FINISH
ENTREES																		
BEEF W/BARBEQUE SAUCE	35	1/4	1/2	3/4	1	___	___	1	2	3	4	5	6	7	8	9	___	___
BEEF W/GRAVY	39	1/4	1/2	3/4	1	___	___	1	2	3	4	5	6	7	8	9	___	___
BEEF W/SPICED SAUCE	43	1/4	1/2	3/4	1	___	___	1	2	3	4	5	6	7	8	9	___	___
BEEF PATTIES	34	1/4	1/2	3/4	1	___	___	1	2	3	4	5	6	7	8	9	___	___
BEEF STEW	36	1/4	1/2	3/4	1	___	___	1	2	3	4	5	6	7	8	9	___	___
CHICKEN ALA KING	40	1/4	1/2	3/4	1	___	___	1	2	3	4	5	6	7	8	9	___	___
FRANKFURTERS	37	1/4	1/2	3/4	1	___	___	1	2	3	4	5	6	7	8	9	___	___
HAM CHICKEN LOAF	33	1/4	1/2	3/4	1	___	___	1	2	3	4	5	6	7	8	9	___	___
HAM SLICES	42	1/4	1/2	3/4	1	___	___	1	2	3	4	5	6	7	8	9	___	___
MEATBALLS W/BARBEQUE SAUCE	41	1/4	1/2	3/4	1	___	___	1	2	3	4	5	6	7	8	9	___	___
PORK SAUSAGE PATTIES	32	1/4	1/2	3/4	1	___	___	1	2	3	4	5	6	7	8	9	___	___
TURKEY W/GRAVY	38	1/4	1/2	3/4	1	___	___	1	2	3	4	5	6	7	8	9	___	___
STARCH																		
CRACKERS	48	1/4	1/2	3/4	1	___	___	1	2	3	4	5	6	7	8	9	___	___
BEANS W/TOMATO SAUCE	46	1/4	1/2	3/4	1	___	___	1	2	3	4	5	6	7	8	9	___	___
POTATO PATTY	61	1/4	1/2	3/4	1	___	___	1	2	3	4	5	6	7	8	9	___	___
SPREAD																		
CHEESE	31	1/4	1/2	3/4	1	___	___	1	2	3	4	5	6	7	8	9	___	___
JELLY	73	1/4	1/2	3/4	1	___	___	1	2	3	4	5	6	7	8	9	___	___
PEANUT BUTTER	47	1/4	1/2	3/4	1	___	___	1	2	3	4	5	6	7	8	9	___	___
FRUIT																		
APPLESAUCE	57	1/4	1/2	3/4	1	___	___	1	2	3	4	5	6	7	8	9	___	___
MIXED FRUITS	60	1/4	1/2	3/4	1	___	___	1	2	3	4	5	6	7	8	9	___	___
PEACHES	59	1/4	1/2	3/4	1	___	___	1	2	3	4	5	6	7	8	9	___	___
STRAWBERRIES	58	1/4	1/2	3/4	1	___	___	1	2	3	4	5	6	7	8	9	___	___
OTHER																		
CATSUP	62	1/4	1/2	3/4	1	___	___	1	2	3	4	5	6	7	8	9	___	___
GRAVY BASE (SOUP MIX)	29	1/4	1/2	3/4	1	___	___	1	2	3	4	5	6	7	8	9	___	___
SALT	77	1/4	1/2	3/4	1	___	___	1	2	3	4	5	6	7	8	9	___	___

DAY 3

MRE RATION CONSUMPTION (CONT)

CIRCLE THE NUMBER THAT INDICATES HOW MUCH OF EACH ITEM YOU ATE TODAY. *THE TOTAL AMOUNT OF EACH ITEM IS SHOWN IN PARENTHESIS IN* BAR OR PACKAGE (PKT) UNITS. IF YOU EAT AN AMOUNT THAT IS NOT LISTED WRITE IT ON THE LINE TO THE RIGHT. FOR EXAMPLE: IF YOU EAT 2 CHICKEN STEW BARS CIRCLE 2. IF YOU EAT 2½ BARS, WRITE IN 2½. IF YOU EAT 5 BARS WRITE IN 5.

ADDED WATER

PLEASE LIST THE *AMOUNT OF WATER* YOU ADDED TO EACH FOOD OR BEVERAGE ITEM. WRITE IN "0" IF YOU DID NOT ADD WATER TO A FOOD YOU ATE.

DAY 3

RATING OF FOOD

PLEASE CIRCLE THE NUMBERS THAT INDICATE HOW MUCH YOU LIKED OR DISLIKED THE *RATION ITEM THAT YOU ATE TODAY.*

REASONS FOR NOT EATING/FINISHING

PLEASE WRITE IN THE NUMBERS OF THE PRIMARY REASON THAT YOU DIDN'T FINISH AN ITEM OR DID NOT EAT THE ITEM AT ALL. IF YOUR PRIMARY REASON IS NOT LISTED, WRITE IT IN.

1 SPILLED	9 UNABLE TO HEAT
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5 DIETING	13 TOO SALTY
6 LOOKED BAD	14 SAVED FOR LATER MEAL
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8 TRADED	16 TOO MUCH TROUBLE

FOOD ITEM	CODE	AMOUNT CONSUMED (BY PACKAGE)					WATER (IN CANTEEN CUPS) (1/4, 1/2, 3/4, 1, ETC.)	DISLIKE EXTREMELY	DISLIKE VERY MUCH	DISLIKE MODERATELY	DISLIKE SLIGHTLY	NEITHER LIKE/DISLIKE	LIKE SLIGHTLY	LIKE MODERATELY	LIKE VERY MUCH	LIKE EXTREMELY	DID NOT EAT	DID NOT FINISH
DESSERT																		
BROWNIE	51	1/4	1/2	3/4	1	___	___	1	2	3	4	5	6	7	8	9	___	___
CHERRY NUT CAKE	52	1/4	1/2	3/4	1	___	___	1	2	3	4	5	6	7	8	9	___	___
CHOCOLATE COVERED COOKIE	49	1/4	1/2	3/4	1	___	___	1	2	3	4	5	6	7	8	9	___	___
FRUITCAKE	54	1/4	1/2	3/4	1	___	___	1	2	3	4	5	6	7	8	9	___	___
MAPLE NUT CAKE	53	1/4	1/2	3/4	1	___	___	1	2	3	4	5	6	7	8	9	___	___
ORANGE NUT CAKE	56	1/4	1/2	3/4	1	___	___	1	2	3	4	5	6	7	8	9	___	___
PINEAPPLE NUT CAKE	50	1/4	1/2	3/4	1	___	___	1	2	3	4	5	6	7	8	9	___	___
CHOCOLATE NUT CAKE	55	1/4	1/2	3/4	1	___	___	1	2	3	4	5	6	7	8	9	___	___
BEVERAGE																		
COCOA POWDER	63	1/4	1/2	3/4	1	___	___	1	2	3	4	5	6	7	8	9	___	___
COFFEE	64	1/4	1/2	3/4	1	___	___	1	2	3	4	5	6	7	8	9	___	___
CREAM SUBSTITUTE	30	1/4	1/2	3/4	1	___	___	1	2	3	4	5	6	7	8	9	___	___
SUGAR	74	1/4	1/2	3/4	1	___	___	1	2	3	4	5	6	7	8	9	___	___
OTHER																		
CANDY (ALL TYPES)	76	1/4	1/2	3/4	1	___	___	1	2	3	4	5	6	7	8	9	___	___
GUM	78	1/4	1/2	3/4	1	___	___	1	2	3	4	5	6	7	8	9	___	___
___						___	___	1	2	3	4	5	6	7	8	9	___	___
___						___	___	1	2	3	4	5	6	7	8	9	___	___

DAY 3

WATER CONSUMPTION

CIRCLE THE TOTAL AMOUNT OF UNFLAVORED WATER THAT YOU DRINK OR USE DURING EACH PERIOD. DO NOT RECORD FLAVORED WATER SUCH AS TEA, ORANGE BEVERAGE, ETC. HERE. IF YOU DRINK OR USE MORE THAN TWO CANTEENS DURING ONE PERIOD, WRITE THE TOTAL AMOUNT ON THE LINE PROVIDED.

	DRINKING	OTHER (WASHING, ETC.)
DURING BREAKFAST	(CODE 10) 1/4 1/2 3/4 1 1 1/4 1 1/2 1 3/4 2 OR ___ CANTEENS	(CODE 11) 1/4 1/2 3/4 1 1 1/4 1 1/2 1 3/4 2 OR ___ CANTEENS
BETWEEN BREAKFAST AND LUNCH	(CODE 20) 1/4 1/2 3/4 1 1 1/4 1 1/2 1 3/4 2 OR ___ CANTEENS	(CODE 21) 1/4 1/2 3/4 1 1 1/4 1 1/2 1 3/4 2 OR ___ CANTEENS
DURING LUNCH	(CODE 30) 1/4 1/2 3/4 1 1 1/4 1 1/2 1 3/4 2 OR ___ CANTEENS	(CODE 31) 1/4 1/2 3/4 1 1 1/4 1 1/2 1 3/4 2 OR ___ CANTEENS
BETWEEN LUNCH AND DINNER	(CODE 40) 1/4 1/2 3/4 1 1 1/4 1 1/2 1 3/4 2 OR ___ CANTEENS	(CODE 41) 1/4 1/2 3/4 1 1 1/4 1 1/2 1 3/4 2 OR ___ CANTEENS
DURING DINNER	(CODE 50) 1/4 1/2 3/4 1 1 1/4 1 1/2 1 3/4 2 OR ___ CANTEENS	(CODE 51) 1/4 1/2 3/4 1 1 1/4 1 1/2 1 3/4 2 OR ___ CANTEENS
BETWEEN DINNER AND BREAKFAST	(CODE 60) 1/4 1/2 3/4 1 1 1/4 1 1/2 1 3/4 2 OR ___ CANTEENS	(CODE 61) 1/4 1/2 3/4 1 1 1/4 1 1/2 1 3/4 2 OR ___ CANTEENS
DAILY TOTAL	(CODE 70) ___ CANTEENS	(CODE 71) ___ CANTEENS

DAY 3

PLEASE ANSWER THE FOLLOWING QUESTIONS. CIRCLE ONE NUMBER TO ANSWER EACH QUESTION.

1. How LIGHT or DARK is your urine today?

EXTREMELY LIGHT	MODERATELY LIGHT	SLIGHTLY LIGHT	NEITHER LIGHT NOR DARK	SLIGHTLY DARK	MODERATELY DARK	EXTREMELY DARK
1	2	3	4	5	6	7

2. Rate the COLOR of your urine as it has occurred today.

LIGHT YELLOW	DARK YELLOW	ORANGE	BROWN
1	2	3	4

3. Are you urinating more or less OFTEN than usual?

EXTREMELY LESS	MODERATELY LESS	SLIGHTLY LESS	NEITHER MORE NOR LESS	SLIGHTLY MORE	MODERATELY MORE	EXTREMELY MORE
1	2	3	4	5	6	7

4. Is the AMOUNT you are urinating more or less than usual?

EXTREMELY LESS	MODERATELY LESS	SLIGHTLY LESS	NEITHER MORE NOR LESS	SLIGHTLY MORE	MODERATELY MORE	EXTREMELY MORE
1	2	3	4	5	6	7

5. Does your MOUTH feel DRY?

NOT AT ALL	SLIGHTLY	SOMEWHAT	MODERATELY	QUITE A BIT	EXTREMELY
1	2	3	4	5	6

6. Does your SKIN feel LOOSE or LIMP?

NOT AT ALL	SLIGHTLY	SOMEWHAT	MODERATELY	QUITE A BIT	EXTREMELY
1	2	3	4	5	6

7. Are you THIRSTY?

NOT AT ALL	SLIGHTLY	SOMEWHAT	MODERATELY	QUITE A BIT	EXTREMELY
1	2	3	4	5	6

8. Are you TIRED?

NOT AT ALL	SLIGHTLY	SOMEWHAT	MODERATELY	QUITE A BIT	EXTREMELY
1	2	3	4	5	6

9. Are you CONSTIPATED?

NOT AT ALL	SLIGHTLY	SOMEWHAT	MODERATELY	QUITE A BIT	EXTREMELY
1	2	3	4	5	6

10. How is your morale?

EXTREMELY LOW	MODERATELY LOW	SLIGHTLY LOW	NEITHER HIGH NOR LOW	SLIGHTLY HIGH	MODERATELY HIGH	EXTREMELY HIGH
1	2	3	4	5	6	7

MRE RECORD - MENU 3

NAME: ______________________ -　　　　JULIAN DATE: 85 __________

SUBJECT NUMBER #: ______________　　　　DATA COLLECTOR #: __________

DATE: ______________________　　　　DATA ENTERER #: __________

WHICH MEAL? B - Breakfast L - Lunch D - Dinner (Circle appropriate letter)

CODES FOR REASONS NOT EATEN: (Choose primary reason)

1 - Don't like	6 - Too tough	11 - Too bland	16 - No water for rehydration
2 - Dieting	7 - Too mushy	12 - Not enough time	17 - Portion too big
3 - Not hungry	8 - Too salty	13 - Saved	18 - Prefer next meal's ration type
4 - Smelled bad	9 - Too spicy	14 - Traded	19 - Other
5 - Looked bad	10 - Too sweet	15 - Spilled	

CODES FOR RATING:

0 - Didn't try	5 - Neither like nor dislike
1 - Dislike extremely	6 - Like slightly
2 - Dislike very much	7 - Like moderately
3 - Dislike moderately	8 - Like very much
4 - Dislike slightly	9 - Like extremely

REMEMBER: Each item was either eaten or not eaten, and must be accounted for in columns 1 or 2.

COLUMN 1: Enter code (1-19) for reason not eaten or not finished.
COLUMN 2: Circle amount eaten.
COLUMN 3: Enter code (0-9) for rating.

FOOD ITEM	Code ID	REASON NOT EATEN OR NOT FINISHED (1)	AMOUNT EATEN (2)	RATING (3)
			3/4	
BEANS W/TOMATO SAUCE	(140)		0 1/4 1/2 1/3 1 2 3	
BEEF PATTY	(127)		0 1/4 1/2 1/3 1 2 3	
CRACKERS	(146)		0 1/4 1/2 1/3 1 2 3	
CHEESE SPREAD	(164)		0 1/4 1/2 1/3 1 2 3	
BROWNIES CHCV	(149)		0 1/4 1/2 1/3 1 2 3	
SOUP/GRAVY BASE	(167)		0 1/4 1/2 1/3 1 2 3	
COFFEE	(123)		0 1/4 1/2 1/3 1 2 3	
CREAM SUBSTITUTE	(124)		0 1/4 1/2 1/3 1 2 3	
SUGAR	(333)		0 1/4 1/2 1/3 1 2 3	
SALT	(330)		0 1/4 1/2 1/3 1 2 3	
HOT SAUCE	(382)		0 1/4 1/2 1/3 1 2 3	
CANDY ________	( )		0 1/4 1/2 1/3 1 2 3	

OTHER: Any item gained thru trade, saved, etc.

			0 1/4 1/2 1/3 1 2 3	
			0 1/4 1/2 1/3 1 2 3	
			0 1/4 1/2 1/3 1 2 3	

Please place all empty wrappers and discarded foods in ziplock bag and return. Record items saved or traded away in reason column.

NATICK Form 612c (ONE-TIME)
1 Jul 85

MRE RATION CONSUMPTION

Entree	Cde	(1) Amount eaten	(2) Rating	(3) Reason(s) not eaten/ finished	(4) Added water	(5) Heated
Beef-BBQ	08	____	____	____	____	____
Beef-corned hash	21	____	____	____	____	____
Beef-gravy	12	____	____	____	____	____
Beef patty	07	____	____	____	____	____
Beef-sliced	18	____	____	____	____	____
Beef-spicy	16	____	____	____	____	____
Beef stew	09	____	____	____	____	____
Beef stew 8oz	26	____	____	____	____	____
Chix ala king	13	____	____	____	____	____
Chix ala king 8oz	25	____	____	____	____	____
Chicken loaf	19	____	____	____	____	____
Chicken-rice	29	____	____	____	____	____
Chicken stew	22	____	____	____	____	____
Frankfurter	10	____	____	____	____	____
Ham/Chicken loaf	06	____	____	____	____	____
Ham omelet	23	____	____	____	____	____
Ham-potatoes	30	____	____	____	____	____
Ham slices	15	____	____	____	____	____
Meatballs-BBQ	14	____	____	____	____	____
Meatballs-rice	27	____	____	____	____	____
Pork patty	05	____	____	____	____	____
Pork-rice	20	____	____	____	____	____
Spaghetti-Mtsauce	24	____	____	____	____	____
Tuna-noodles	28	____	____	____	____	____
Turkey-gravy	11	____	____	____	____	____
Starches						
Beans-Tomatosauce	17	____	____	____	____	____
Crackers	41	____	____	____	____	____
Potato, chix sce	32	____	____	____	____	____
Potato patty	31	____	____	____	____	____
Spread						
Cheese	63	____	____	____	____	____
Jelly	64	____	____	____	____	____
Peanut Butter	67	____	____	____	____	____

Name:________________

Date:________________

Subject Number:________

DIRECTIONS

(1) For every food item eaten in one 24 hr time period, please indicate in column (1) how much you ate (ie:1/4,1/2,3/4,1,2,3,etc.)

(2) In column (2), please rate each food item on a scale of 1-9 indicating your like/dislike of each item.

1=dislike extremely	5=neither like/ dislike
2=dislike very much	6=like slightly
3=dislike moderately	7=like moderately
4=dislike slightly	8=like very much
	9=like extremely

(3) For each food item that you did not eat or did not finish, please indicate in column (3) the primary reason for not eating/ finishing that food item. If your primary reason is not listed, write it in.

1=didn't want	6=not thirsty
2=traded	7=don't like
3=saved	8=don't use
4=too busy	9=unable to heat
5=not hungry	10=tasted bad
	11=ration too big

12=other(specify):__________

(4) In column (4) please indicate the amount of water that you used in canteen cups to rehydrate any food/beverage.

(5) In column (5) please check (✓) each item heated prior to eating.

(6) On reverse side, please indicate the amount of plain water that you drank from your canteen every 6 hrs (ie: 1/2 canteen, 2-1/4 canteens etc.)

NATICK Form 649 (ONE-TIME)
1 May 86

	Cde	(1) Amount eaten	(2) Rating	(3) Reason(s) not eaten/ Finished	(4) Added water	(5) Heated
Fruit						
Applesauce	33	____	____	____	____	____
Fruit mix-dehydr	36	____	____	____	____	____
Fruit Mix	40	____	____	____	____	____
Peaches	39	____	____	____	____	____
Peaches-dehydr	35	____	____	____	____	____
Pears	37	____	____	____	____	____
Pineapple	38	____	____	____	____	____
Strawberries	34	____	____	____	____	____
Dessert						
Brownie	46	____	____	____	____	____
Cherry Nut Cake	47	____	____	____	____	____
Choc Cov Cookie	44	____	____	____	____	____
Choc Nut Cake	50	____	____	____	____	____
Fruit Cake	49	____	____	____	____	____
Granola Bar	43	____	____	____	____	____
Maple Nut Cake	48	____	____	____	____	____
Orange Nut Cake	51	____	____	____	____	____
Pineapple Nut Cake	45	____	____	____	____	____
Beverage						
Beverage Base	02	____	____	____	____	____
Cocoa Powder	03	____	____	____	____	____
Coffee-instant	04	____	____	____	____	____
Condiments						
Catsup	65	____	____	____	____	____
Cream Substitute	01	____	____	____	____	____
Gravy/soup mix	66	____	____	____	____	____
Salt	70	____	____	____	____	____
Sugar	69	____	____	____	____	____
Tabasco Sauce	68	____	____	____	____	____
Other						
Gum	59	____				
Candy	__	____	____	____	____	____
(Specify):	________					
	________					

Other ____________

(Specify): ____________

RATINGS

1=dislike extremely	5=neither like/ dislike
2=dislike very much	6-like slightly
3=dislike moderately	7=like moderately
4-dislike slightly	8=like very much
	9=like extremely

REASONS NOT EATEN/ FINISHED

1=didn't want	6=not thirsty
2=traded	7=don't like
3=saved	8=don't use
4=too busy	9=unable to heat
5=not hungry	10=tasted bad
	11=ration too big

12=other(specify)____________

(6)

Water Consumption

0800-1400__________Canteens

1400-2000__________Canteens

2000-0200__________Canteens

0200-0800__________Canteens

SNACK RECORD

NAME: ____________________ JULIAN DATE: 85______

SUBJECT #: ____________________ DATA COLLECTOR #: ______

DATE: ____________________ DATA ENTERER #: ______

FOOD RATINGS:

0 - Didn't try
1 - Dislike extremely
2 - Dislike very much
3 - Dislike moderately
4 - Dislike slightly
5 - Neither like nor dislike
6 - Like slightly
7 - Like moderately
8 - Like very much
9 - Like extremely

FOOD TYPE	DESCRIPTION	ID CODE	AMOUNT EATEN (Circle one)						FOOD RATING CODE (0-9)
ENTREE	Beef w/Bbq Sauce	(128)	1/4	1/2	3/4	1	2	3	______
	Beef w/Gravy	(132)	1/4	1/2	3/4	1	2	3	______
	Beef w/Spicy Sauce	(139)	1/4	1/2	3/4	1	2	3	______
	Beef Patty	(127)	1/4	1/2	3/4	1	2	3	______
	Beef Stew	(129)	1/4	1/2	3/4	1	2	3	______
	Chicken Ala King	(136)	1/4	1/2	3/4	1	2	3	______
	Frankfurters	(130)	1/4	1/2	3/4	1	2	3	______
	Ham/Chicken Loaf	(126)	1/4	1/2	3/4	1	2	3	______
	Ham Slices	(138)	1/4	1/2	3/4	1	2	3	______
	Meatballs w/Bbq Sauce	(137)	1/4	1/2	3/4	1	2	3	______
	Pork Sausage Patty	(125)	1/4	1/2	3/4	1	2	3	______
	Turkey w/Gravy	(131)	1/4	1/2	3/4	1	2	3	______
STARCH	Crackers	(146)	1/4	1/2	3/4	1	2	3	______
	Beans w/Tomato Sauce	(140)	1/4	1/2	3/4	1	2	3	______
	Potato Patty	(141)	1/4	1/2	3/4	1	2	3	______
SPREAD	Cheese	(164)	1/4	1/2	3/4	1	2	3	______
	Peanut Butter	(395)	1/4	1/2	3/4	1	2	3	______
	Jelly	(165)	1/4	1/2	3/4	1	2	3	______
FRUIT	Applesauce	(142)	1/4	1/2	3/4	1	2	3	______
	Fruit Mix	(145)	1/4	1/2	3/4	1	2	3	______
	Peaches	(144)	1/4	1/2	3/4	1	2	3	______
	Strawberries	(143)	1/4	1/2	3/4	1	2	3	______
DESSERT	Brownie	(149)	1/4	1/2	3/4	1	2	3	______
	Cherry Nut Cake	(150)	1/4	1/2	3/4	1	2	3	______
	Chocolate-covered Cookie	(147)	1/4	1/2	3/4	1	2	3	______
	Fruitcake	(152)	1/4	1/2	3/4	1	2	3	______
	Maple Nut Cake	(151)	1/4	1/2	3/4	1	2	3	______
	Orange Nut Roll	(154)	1/4	1/2	3/4	1	2	3	______
	Chocolate Nut Cake	(153)	1/4	1/2	3/4	1	2	3	______
	Pineapple Nut Cake	(148)	1/4	1/2	3/4	1	2	3	______
BEVERAGE	Cocoa	(122)	1/4	1/2	3/4	1	2	3	______
	Coffee	(123)	1/4	1/2	3/4	1	2	3	______
OTHER	Cream Substitute	(124)	1/4	1/2	3/4	1	2	3	______
	Sugar	(333)	1/4	1/2	3/4	1	2	3	______
	Salt Packet	(330)	1/4	1/2	3/4	1	2	3	______
	Hot Sauce	(382)	1/4	1/2	3/4	1	2	3	______
	Catsup	(166)	1/4	1/2	3/4	1	2	3	______
	Soup/Gravy Base	(167)	1/4	1/2	3/4	1	2	3	______
	Candy ______	( )	1/4	1/2	3/4	1	2	3	______
	______	( )	1/4	1/2	3/4	1	2	3	______
	______	( )	1/4	1/2	3/4	1	2	3	______

Please place all empty wrappers and discarded foods in ziplock bag and return with card.

NATICK Form 614 (ONE-TIME)
1 Jul 85

WATER RECORD CARD

NAME: ____________________ JULIAN DATE: ____________________
SUBJECT NUMBER: ____________________ DATA COLLECTOR #: ____________________
DATE: ____________________ DATA ENTERER #: ____________________

TIME: (Circle one) 1 - Breakfast to Dinner 2 - Dinner to Breakfast

---

TOTAL (In Canteens)
Circle total as you refill

1	1	1	1
¾	¾	¾	¾
½	½	½	½
¼	¼	¼	¼

TOTAL ________

DRINKING (In Canteens)
Circle total

1	1	1	1
¾	¾	¾	¾
½	½	½	½
¼	¼	¼	¼

TOTAL ________

REHYDRATION FOOD
Circle quantity rehydrated; omit if none or eaten dry

Potato Patty	1	2	3	________
Beef Patty	1	2	3	________
Pork Patty	1	2	3	________
Strawberries	1	2	3	________
Peaches	1	2	3	________
Fruit Mix	1	2	3	________

TOTAL ________

REHYDRATION BEVERAGES
Circle quantity rehydrated

Coffee	1	2	3	4	________
Cocoa	1	2	3	4	________

TOTAL ________

HEATING ENTREES (In Cups)
Circle quantity used; omit if eaten cold

1	1	1	1
¾	¾	¾	¾
½	½	½	½
¼	¼	¼	¼

TOTAL ________

OTHER
Circle total
e.g., brushing teeth, washing, etc.

1	1	1	1
¾	¾	¾	¾
½	½	½	½
¼	¼	¼	¼

TOTAL ________

NATICK Form 615 (ONE-TIME)
1 Jul 85

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UNITED KINGDOM

24 HOUR ARCTIC RATION - QUESTIONNAIRE

HAVING JUST EATEN ARCTIC RATION PACKS, THIS QUESTIONNAIRE IS DESIGNED TO FIND OUT YOUR HONEST OPINION OF VARIOUS ASPECTS OF THESE PACKS. YOUR ANSWERS TO THESE QUESTIONS ARE EXTREMELY IMPORTANT TO THE FUTURE DEVELOPMENT OF VARIOUS RATION PACKS. WOULD YOU PLEASE THEREFORE COMPLETE EACH PART AS FULLY AND AS CAREFULLY AS YOU CAN.

DO NOT WRITE HERE

1. What is the last number of your Regimental Number? [ ] Tick here — 1

2. What is your rank group? (Please indicate by a tick against the appropriate group listed)

Officer		1		
Senior Rank(Sgt.or above)		2	2	
Junior Rank(Cpl or below)		3		

3. Are you?

Married		1	3
Single		2	

4. In which year were you born? 19[ ][ ] — 4-5

5. Approximately how many minutes did it take to prepare meals (Please circle one number against each meal)

	Less than 15 Minutes	15-30 Minutes	30-45 Minutes	45-60 Minutes	More than 60 Minutes	
	1	2	3	4	5	
a) Breakfast	1	2	3	4	5	6
b) Snack	1	2	3	4	5	7
c) Main meal	1	2	3	4	5	8

DO NOT WRITE HERE

6. Please rate how satisfied or dissatisfied you are with each of the following aspects of the Arctic Ration Pack. (please circle one number against each aspect)

	Very Dis-satisfied	Dis-satisfied	Neither Dis-satisfied nor satisfied	Satisfied	Very satis-fied	
	1	2	3	4	5	
a. Weight of the pack	1	2	3	4	5	9
b. Ease of carrying the food e.g. in webbing and pouches	1	2	3	4	5	10
c. Overall volume (i.e. size) of the pack	1	2	3	4	5	11
d. Overall packaging of the rations	1	2	3	4	5	12
e. Ease with which dried foods can be re-constituted	1	2	3	4	5	13
f. Ease with which food can be heated	1	2	3	4	5	14
g. Taste of food	1	2	3	4	5	15
h. Total amount of food provided in each pack	1	2	3	4	5	16

7. When did you normally eat the meals? — Tick here

a. At 'normal' meal times	[ ]	1	
b. Throughout the day as time permitted	[ ]	2	17
c. Combination of a and b	[ ]	3	

-3-

8. How well did you like or dislike the contents of the Arctic Pack and how much of them did you eat?

Against each food item would you please circle one number in the 'Dislike-Like' section and one number in the 'Amount Eaten' section.

	Not eaten on this exercise	DISLIKE Very much	Moderately	Slightly	Neutral	LIKE Slightly	Moderately	Very much	AMOUNT EATEN all	¾	½	¼	none	DO NOT WRITE HERE
	0	1	2	3	4	5	6	7	all	¾	½	¼	none	

Example: If you dislike slightly the 'Beef Granules' and only ate half of the amount please mark accordingly.

Beef Granules	0	1	2	3	4	5	6	7	all	¾	½	¼	none	
a. Rolled oats	0	1	2	3	4	5	6	7	all	¾	½	¼	none	18-19
b. Drinking Chocolate	0	1	2	3	4	5	6	7	all	¾	½	¼	none	20-21
c. Plain Biscuits	0	1	2	3	4	5	6	7	all	¾	½	¼	none	22-23
d. Fruit Biscuits	0	1	2	3	4	5	6	7	all	¾	½	¼	none	24-25
e. Milk Chocolate	0	1	2	3	4	5	6	7	all	¾	½	¼	none	26-27
f. Chocolate Biscuits	0	1	2	3	4	5	6	7	all	¾	½	¼	none	28-29
g. Rolo	0	1	2	3	4	5	6	7	all	¾	½	¼	none	30-31
h. Nuts & Rasins	0	1	2	3	4	5	6	7	all	¾	½	¼	none	32-33
i. Dextrose Tablets	0	1	2	3	4	5	6	7	all	¾	½	¼	none	34-35
j. Beef Spread	0	1	2	3	4	5	6	7	all	¾	½	¼	none	36-37
k. Chicken Spread	0	1	2	3	4	5	6	7	all	¾	½	¼	none	38-39
l. Chicken & Bacon Spread	0	1	2	3	4	5	6	7	all	¾	½	¼	none	40-41

-4-

8. (contd)

	not eaten this exercise	DISLIKE Very much	Moderately	Slightly	Neutral	LIKE Slightly	Moderately	Very Much	AMOUNT EATEN all	¾	½	¼	none	DO NOT WRITE HERE
	0	1	2	3	4	5	6	7	all	¾	½	¼	none	
m. Ham spread	0	1	2	3	4	5	6	7	all	¾	½	¼	none	42-43
n. Chicken spread	0	1	2	3	4	5	6	7	all	¾	½	¼	none	44-45
o. Vegetable soup	0	1	2	3	4	5	6	7	all	¾	½	¼	none	46-47
p. Oxtail soup	0	1	2	3	4	5	6	7	all	¾	½	¼	none	48-49
q. Beef granules	0	1	2	3	4	5	6	7	all	¾	½	¼	none	50-51
r. Curried beef granules	0	1	2	3	4	5	6	7	all	¾	½	¼	none	52-53
s. Mutton granules	0	1	2	3	4	5	6	7	all	¾	½	¼	none	54-55
t. Chicken supreme	0	1	2	3	4	5	6	7	all	¾	½	¼	none	56-57
u. Potato powder	0	1	2	3	4	5	6	7	all	¾	½	¼	none	58-59
v. Pre-cooked Rice	0	1	2	3	4	5	6	7	all	¾	½	¼	none	60-61
w. Dried peas	0	1	2	3	4	5	6	7	all	¾	½	¼	none	62-63
x. Apple flakes	0	1	2	3	4	5	6	7	all	¾	½	¼	none	64-65
y. Apple & Apricot flakes	0	1	2	3	4	5	6	7	all	¾	½	¼	none	66-67
z. Instant coffee	0	1	2	3	4	5	6	7	all	¾	½	¼	none	68-69
aa. Instant tea	0	1	2	3	4	5	6	7	all	¾	½	¼	none	70-71
bb. Beef stock drink	0	1	2	3	4	5	6	7	all	¾	½	¼	none	72-73
cc. Milk powder	0	1	2	3	4	5	6	7	all	¾	½	¼	none	74-75
dd. Sugar	0	1	2	3	4	5	6	7	all	¾	½	¼	none	76-77
[illegible]	[illegible]	1	2	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

DO NOT WRITE HERE

9. How adequate was the variety of food provided? (Please circle one number against each component)

	Very Adequate 1	Adequate 2	Neutral 3	Inadequate 4	Very Inadequate 5	DO NOT WRITE HERE
a. Breakfast	1	2	3	4	5	1
b. Drinks	1	2	3	4	5	2
c. Spreads	1	2	3	4	5	3
d. Soups	1	2	3	4	5	4
e. Main meals	1	2	3	4	5	5
f. Vegetables	1	2	3	4	5	6
g. Puddings	1	2	3	4	5	7
h. Chocolates	1	2	3	4	5	8

10. If you received but did not eat any food items, please indicate why not. Please tick against those statements which most closely apply.

	Tick here	DO NOT WRITE HERE
a. Disliked the taste of the food		9
b. Threw it away		10
c. Not enough time to spare		11
d. Too much trouble or effort to prepare in the cold		12
e. Too cold to stop and eat		13
f. Swapped them for something else		14
g. Any other reason (Please specify below)		15
______________________		16
______________________		17
______________________		18

DO NOT WRITE HERE

11. Were you able to get sufficient water to prepare your food? (Please circle one number)

ALWAYS	ALMOST ALWAYS	OFTEN	FAIRLY OFTEN	SOMETIMES	ALMOST NEVER	NEVER	DO NOT WRITE HERE
1	2	3	4	5	6	7	19

12. Were you able to get sufficient water to satisfy your thirst? (Please circle one number)

ALWAYS	ALMOST ALWAYS	OFTEN	FAIRLY OFTEN	SOMETIMES	ALMOST NEVER	NEVER	
1	2	3	4	5	6	7	20

13. How difficult was it to obtain water? (Please circle one number)

VERY EASY	MODERATELY EASY	FAIRLY EASY	NEITHER EASY NOR DIFFICULT	FAIRLY DIFFICULT	MODERATELY DIFFICULT	VERY DIFFICULT	
1	2	3	4	5	6	7	21

14. On an average day approximately how many bottles of water (or their equivalent) did you get for drinking & eating?(Please circle one number)

Number of Water Bottles:

1	2	3	4	5	6	7plus	22

15. How many times per day did you melt snow & ice to obtain water?(Please circle one number)

ONCE PER DAY	TWICE PER DAY	THREE TIMES PER DAY	FOUR TIMES PER DAY	FIVE OR MORE TIMES PER DAY	
1	2	3	4	5	23

DO NOT WRITE HERE

16. All things considered, how do you rate the meals in the Arctic Ration Pack? (Please circle one number against each meal).

	VERY BAD	MODER-ATELY BAD	FAIRLY BAD	NEITHER BAD NOR GOOD	FAIRLY GOOD	MODER-ATELY GOOD	VERY GOOD	DO NOT WRITE HERE
	1	2	3	4	5	6	7	
Breakfast	1	2	3	4	5	6	7	24
Snack	1	2	3	4	5	6	7	25
Main meal	1	2	3	4	5	6	7	26
Overall	1	2	3	4	5	6	7	27

17. Did you take and consume any privately purchased food & drinks with you? (Please tick)

| Yes | No | 28

If yes, state food or drink purchased

____

____ 29

____ 30

____ 31

____ 32

18. Comments: 33

If you have any further suggestions or comments on improvements or changes to the Arctic Ration Pack please write them in the space below and overleaf.
For example, what additional foods should be included or left out?

THANK YOU FOR COMPLETING THIS QUESTIONNAIRE

UNITED KINGDOM POSTAL SURVEY

ARMY FOOD SURVEY 1984

In answering please tick the appropriate box or enter otherwise as indicated

SECTION 1

1. **What is your rank group?**
   (Please indicate by a tick against the appropriate group listed)

	Tick here		
Officer		1	5
Senior Rank (Sgt or above)		2	
Junior Rank (Cpl or below)		3	

2. **Are you -**

Male		1	6
Female		2	

3. **Are you -**

Married		1	7
Single		2	

4. **Are you -**

Living in		1	8
Living out		2	

5. **In which year were you born?** 19 [ ][ ] 9/10

6. **In which year did you join the Army?** 19 [ ][ ] 11/12

7. **In which type of unit are you serving?**

Junior Leaders Unit/ Apprentice College		1	
Recruit Training Unit		2	13
Field Force Unit		3	
Static or Base Unit		4	

8. **What is your Regt/Corps?**

RAC/Household Cavalry		0	1	
RA		0	2	
RE		0	3	
R Signals		0	4	14/15
Inf/Guards Div/Para		0	5	
RCT		0	6	
RAMC		0	7	
RAOC		0	8	
REME		0	9	
ACC		1	0	
Others		1	1	

9. Where are you serving?

		Tick here		
England Wales Scotland			1	
N Ireland	Permanent Tour		2	16
	Emergency Tour		3	

10. Which part of the country do you originate from?

North – Cleveland, Cumbria, Durham, Northumberland, Tyne and Wear		0	1	
Yorkshire & Humberside – Humberside, North Yorkshire, South Yorkshire, West Yorkshire		0	2	
North West – Cheshire, Lancashire, Greater Manchester, Merseyside		0	3	
East Midlands – Derbyshire, Leicestershire, Lincolnshire, Northamptonshire, Nottinghamshire		0	4	
West Midlands – Hereford and Worcester, Salop, Staffordshire, Warwickshire, West Midlands		0	5	17/18
South West – Avon, Cornwall and the Isles of Scilly, Devon, Dorset, Gloucester, Somerset and Wiltshire		0	6	
South East – Greater London, Bedfordshire, Berkshire, Buckinghamshire, East Sussex, Essex, Hampshire, Hertfordshire, Isle of Wight, Kent, Oxfordshire, Surrey, West Sussex		0	7	
East Anglia – Cambridgeshire, Norfolk, Suffolk		0	8	
Wales		0	9	
Scotland		1	0	
N Ireland		1	1	
Abroad, please specify -				

11. What is your level of education?
    (Please indicate by a tick against the appropriate group listed)

Degree		1	
GCE 'A' level		2	
GCE 'O' level		3	19
EPC(A)		4	
EPC		5	
None of the above		6	

SECTION 2

12. **When eating in Mess or Barracks, how important do you rate these factors?**

(Please tick the boxes which most closely correspond with your views)

Factor	Essential (1)	Of high importance (2)	Of medium importance (3)	Of low importance (4)	Not important (5)	
(a) ENVIRONMENT						
Not having to queue						20
Fast and efficient service						21
Pleasant dining room						22
Cleanliness and appearance of the staff						23
Provision of knives, forks and spoons (Soldiers only)						24
Having no restrictions on what you may wear in the dining room						25
(b) FOOD						
Presentation and appearance of the food						26
Correct temperature of the food						27
For the food to taste good						28
To like the food						29
To have a wide variety of choice						30
To have familiar rather than strange food						31
To have sufficient quantity to eat						32
To eat a healthy balanced diet						33

13. When eating Operational Ration Packs, eg 24 Hour Rations, how important do you rate these factors?

(Please tick the boxes which most closely correspond with your views)

Factor	Essential (1)	Of high importance (2)	Of medium importance (3)	Of low importance (4)	Not important (5)	
(a) PACK						
Light weight						34
Convenient to carry in pouches and webbing						35
(b) FOOD						
Requires the minimum amount of preparation						36
Easy to heat or cook						37
Easy to eat						38
To look appetizing						39
To taste good						40
To like the food						41
To have a wide variety of food						42
To have familiar rather than strange food						43
To have sufficient quantity to eat						44
To eat a healthy balanced diet						45

4

5

14 (a) **Are there any foods or groups of foods which you cannot or are not allowed to eat or which you dislike so intensely that you would never eat?**

(Please tick in the appropriate column those foods which apply)

Food Group	Cannot or not allowed to eat: Allergic to it (1)	Medical (2)	Vegetarian (3)	Religion (4)	Weight-Watching/Dieting (5)	Dislike intensely (6)	
Shellfish (eg prawns, crab)							46
Fish							47
Meat							48
Offal (eg liver)							49
Milk including cream							50
Cheese							51
Eggs							52
Butter and Margarine							53
Vegetables							54
Fruit (including fruit juice)							55
Bread and flour products							56
Tea							57
Coffee							58
Other, please specify -							59/60
							61/62
							63/64

(b) **If you ticked 'Allergic' what effects do they have on you? (Please tick appropriate boxes)**

	Tick here		
Headache, Migraine		1	65
Skin symptoms		1	66
Mouth ulcers, Sore throat		1	67
Giddiness, shaking, fainting		1	68
Aching joints		1	69
Vomiting, diarrhoea, digestive		1	70
Respitory (breathing)		1	71
Other please specify			72

(c) **If you ticked 'Medical', please specify the medical reason** - - - - - - - - - - - - - - - - - - [ ] 73

(d) **If you ticked 'Religion', please specify which religion** - - - - - - - - - - - - - - - - - - [ ] 74

SECTION 4

In this section we are trying to establish how much is known about nutrition. For each of the 12 questions below please select from the 4 answers given the one which you think is correct, by entering the letter code in the appropriate box. (For example if you think the correct answer to Question (b) "You get vitamin C from" is "Cod liver oil" enter 'C' in the box) If you do not know the answer or are unsure, please don't guess, just leave the box blank.

(a) The energy value of a food tells you -
- **A** the number of vitamins it contains
- **B** the number of calories it contains
- **C** the amount of protein it contains
- **D** the amount of iron it contains

[ ] 75

(b) You get vitamin C from -
- **A** milk and cheese
- **B** fruits and vegetables
- **C** cod liver oil
- **D** sunshine

[ ] 76

(c) A person who is active needs more -
- **A** protein
- **B** iron
- **C** calories
- **D** vitamins

[ ] 77

(d) A food which supplies bulk (fibre) in the diet is -
- **A** oatmeal
- **B** yoghurt
- **C** steak
- **D** margarine

[ ] 78

(e) The best way to lose weight is to -
- **A** eat a high carbohydrate diet
- **B** eat a high protein diet
- **C** lift weights
- **D** eat less and exercise more

[ ] 79

(f) The disease caused by not enough iron in the diet is -
- **A** scurvy
- **B** rickets
- **C** anaemia
- **D** diabetes

[ ] 80

(g) The best source of calcium among the following foods is -
- **A** pork chop
- **B** whole grain cereals
- **C** spinach
- **D** cheese

[ ] 81

(h) Which one of the following is highest in polyunsaturated fats -
- **A** butter
- **B** lard
- **C** olive oil
- **D** corn oil

[ ] 82

(i) Margarine and butter are different because -

- A margarine contains less fat than butter
- B margarine contains more saturated fats
- C margarine contains vegetable oil
- D margarine contains fewer calories

[ ] 83

(j) One of the following is not considered to be a risk factor for heart disease -

- A a diet high in animal fat
- B high blood levels of cholesterol
- C a high intake of dietary fibre
- D a high intake of salt

[ ] 84

(k) As you grow older, your body's need for certain nutrients changes in one of the following ways -

- A more vitamin E is required
- B fewer calories are required
- C there is no change
- D more vitamins and minerals are required

[ ] 85

(l) A nutrient which is most likely to be destroyed by heating (boiling, baking etc) is

- A phosphorus
- B vitamin A
- C protein
- D vitamin C

[ ] 86

SECTION 5 GENERAL COMMENTS

If you have any comments or suggestions about how catering in the Army can be improved or changed, please write them in the space below

[ ] 87
[ ] 88
[ ] 89

Thank you for completing this questionnaire

Please return it in the envolope provided through your unit to -

Stats(S)4, Room 503, Tavis House, 1 6 Tavistock Square London WC1H 9NL

PP1/T4196/6/84/WB

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GUIDELINES FOR A HEALTHFUL DIET
ADOPTED BY RSG-8, MAY 1982

GUIDELINES FOR A HEALTHFUL DIET
ADOPTED BY RSG-8, MAY 1982

The following statements are agreed to be useful dietary guidelines for the general military population in order to promote total fitness:

(a) Consume a Wide Variety of Nutritious Foods.

Selection of a diet from a variety of foods including whole grain breads, enriched cereals, dairy products, meats, fish, poultry, eggs, legumes, fruits, and yellow, green and leafy vegetables will provide a well-balanced intake of the required macro- and micronutrients as well as dietary fibre.

(b) Energy Intake Should Equal Energy Expenditure.

Personnel should maintain a desirable body weight by consuming energy in proportion to the amount expended. Excess body fat can be lost most effectively by increasing physical activity and decreasing total food intake, especially fats, oils, refined carbohydrates and alcohol.

(c) Avoid Excessive Dietary Fat Intake.

The proportion of energy in the diet derived from fat sources should not exceed 40% and the agreed desirable goal for military menu planning is 35%. Significant reductions can be made by simply modifying methods of food preparation including trimming and draining of excess fat and baking or broiling foods instead of frying them.

(d) Moderate Salt Intake.

A safe and adequate intake of salt for normal conditions is considered to range between 5 and 10 g of sodium chloride per day. Significant reductions of salt intake can be made by decreasing the amount of salt added at the table and by modifying recipes including the use of other seasonings and herbs.

(e) Maintain Adequate Intake of Dietary Fibre.

This can be done by frequent consumption of a variety of fruits and vegetables and by substituting whole grain products for refined carbohydrates.

A SUMMARY OF THE NUTRIENT RECOMMENDATIONS FOR SELECTED NATO COUNTRIES

Table 1 A Summary of Nutritional Recommendations for Selected NATO Countries

		FAT		CARBOHYDRATE			PROTEIN	FRUITS	VEG	FIBRE	SALT	ALCOHOL	ENERGY BALANCE	CHOLESTEROL
	VARIETY	TYPE	QUANTITY	TYPE	SUGAR	QUANTITY								
RSG-8	R.	Further research	Max 35-40%	I. whole grains D. refined	-----	-----	-----	I.	I.	R.	5-10 g	D.	R.	-----
CA (Govnt)	R.	-----	Max 35%	I.	D.	-----	-----	I.	I.	I.	D.	D.	R	-----
US (DOD)	R.	Personnel at risk	D. Max 35%	I. whole grains	D.	I.	-----	I.	I.	I.	3-8 g	D.	R.	-----
UK (Army)	R.	Max 15% saturated	Max 35%	Unrefined	Max 15%	-----	Max 12% animal & veg.	-----	-----	At least 30 g	Max 10 g	-----	R.	Max 500 mg
NO & DK	-	P/S 1:2 min 3% essential fatty acids	Max 30-50%	-----	Max 10%	50-60%	Max 15%	-----	-----	-----	------	-----	R.	-----
NL	R.	P/S 1:2-1:1	Max 30-35%	Increase complex	15-25%	55%	Shift from animal to vegetable	-----	-----	3 g/MJ	Max 9 g	D.	R.	33 mg/MJ
FRG	-	-----	Max 35-40%	Increase whole grains	D.	-----	Min 60 g animal & vegetable	I.	I.	I.	5-10 g	D.	R.	-----

R. Recommended
I. Increase
D. Decrease

MEMBERSHIP AND ATTENDANCE OF PANEL 8, RESEARCH STUDY GROUP 8.

NUTRITIONAL ASPECTS OF MILITARY FEEDING

Country	1st USA May 82	2nd NL Oct 83	3rd FRG Jun 85	4th CA Oct 86	5th BE Apr 87	6th USA Nov 87
Belgium						
Lt Col J. de Heptine	Y	Y	Y	Y	Y	Y
Canada						
Dr B. H. Sabiston	Y	Y				
Maj N. Bennett		Y	Y	Y	Y	Y
Dr I. Jacobs			Y	Y	Y	Y
Denmark						
Col T. Gregersen	Y	Y	Y	Y	Y	Y
France						
Dr M. Pruvost	Y					
Dr Gervaise		Y				
Germany						
Col E. Sommer	Y	Y	Y+	Y+	Y+	Y+
Greece						
Lt Col A.T. Rantsios	Y	Y				
Netherlands						
Lt Col F.M. Bertina	Y	Y	Y	Y	Y	Y
Prof R. Luyken	Y	Y	Y			
Dr E.J. van der Beek		Y	Y	Y	Y	Y
Norway						
Maj P. Neskleiv			Y	Y	Y	Y
United Kingdom						
Maj Gen J.P. Crowdy	Y*	Y*				
Dr D.J. Smith	Y	Y	Y	Y	Y	Y
Lt Col J.S.A. Edwards		Y	Y	Y	Y	Y
United States						
Col D.D. Schnakenberg	Y+	Y+	Y*	Y*	Y*	Y*
Dr O. Maller	Y					
Lt Col E.W. Askew						Y

* Chairman
\+ Vice Chairman

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